SCIENTIFIC AMERICAN SUPPLEMENT, No. 970

Copyright by Munn & Co., 1894.

Scientific American Supplement, Vol. XXXVIII. No. 970. NEW YORK, AUGUST 4, 1894. Scientific American Supplement, $5 a year. Scientific American, established 1845. Scientific American and Supplement, $7 a year.

THE MODERN WAR GUN.

"THE ball is crazy, the bayonet alone is sensible," said the brave Souwarof after forcing the lines of Joubert at Novi. The Russian general had some reason for speaking thus. In one of his attacks he had the audacity to have his grave dug by his grenadiers under the fire of the French foot soldiers. "If you do not advance," exclaimed he to his troops, "you will bury me here." Legend or not, it must be agreed that guns were not very formidable at this epoch.

Souwarof and Joubert would be obliged to change their opinion were they to return among us, for owing to the adoption of rifled arms loaded at the breech, the fire of the infantry has become much more efficacious.

The war of 1866 marks the starting point of a true revolution in armament. We think it superfluous to rewrite here the history of the chassepot, and to pass in review all the improvements of detail made for a period of twenty years up to 1885.

It seems to us more useful to sketch a comparative study of the various types of war guns now in use among the principal powers.

In France, the last type adopted is, as well known, the 1886 model, called the Lebel gun. The preparatory work of the School of Chalons upon movable breeches and upon projectiles, and the discovery of a new explosive by Engineer Vieille, have permitted of uniting the majority of the conditions required for a weapon of small caliber and rapid fire.

However, the system of repetition might be better. There has been too much haste to adopt a mechanism that is already old, since in America Lee devised a very practical magazine that, through a single spring, carried the cartridges one by one to the breech box, and, in Germany, Mannlicher still further simplified and improved (if that were possible) the invention of Lee.

However this may be, the successive transformations made in armament from 1887 to 1889 are derived from the principles applied in inventions of French, American or Austrian origin. The three models that we represent herewith show us the latest improvements made by the manufacturers in France and other countries. They much resemble one another externally, and differ only in the movable breech and the system of repetition.

The Daudeteau gun is provided with a movable breech analogous to that of the Lebel gun. Ingenious arrangements permit of filling the magazine by a single movement of the thumb, by the aid of a fire-cartridge loader, or else of introducing the cartridges thereinto, one by one, with the fingers. The weapon may be used for firing shot by shot, the magazine being filled or not.

The latest type of the Mauser gun here shown is the least simple of the three weapons. The assembling of the various pieces of the movable breech leaves much to be desired, and although it has been possible to conceal the magazine in the stock, it has been at the cost of complications that ought to be avoided in weapons of war. This loader is not very strong. The Mannlicher gun, manufactured at Steyr (Austria), is a very strong weapon. Its breech closer is simple, and its repeating mechanism has but one defect, and that is of requiring loaders. If the latter chance to give out, the weapon cannot be supplied and the loading of it charge by charge is very difficult. Moreover, the fire-cartridge loaders are very well adapted for packing, and keep the ammunition in a good state.

These three 6·5 mm. guns fire balls of about 10 grammes with an initial velocity of 730 meters, in the case of the first, and of 710 meters in that of the two others. The ball of the Daudeteau gun traverses at 50 meters 1·45 meter of juxtaposed spruce planks, or 12 mm. of hard steel.

The following are some figures that will give an idea of the progress of ballistics during the last twenty years that is to say since the adoption of the 1878 model of the Gras gun. This weapon used a cartridge weighing 43 grammes, the ball of which, propelled with a velocity of 450 meters, was capable, without the aid of the breech-sight, of sweeping the ground up to about 45 meters. At great distances, toward about 400 meters, for example, the dangerous zone for a standing man was 9·4 meters. The expression "Sweeping the ground," we use purposely. In fact, at the

The Charger of the Mauser Gun.

distances at which battles will take place in the future the enemy will no longer be seen, but an endeavor will be made to render the ground that he occupies untenable. It will therefore be necessary for the infantry officer to be able to estimate distances accurately, and to recognize at once the grounds whose inclination recedes from or approaches the curve of the trajectory, in order to obtain as often as possible a rasant fire and avoid a darting one.

After a comparative examination of the most recent 6½ mm. models, a question very naturally arises: Is it possible to obtain a more reduced caliber? With the Lebel, whose cartridge weighs 29 grammes, the 15 gramme ball has a velocity of 615 meters. A shot may be fired without the breech-sight as far as to about 600 meters. At 1,400 meters the dangerous zone for a man standing is 17 meters.

As for the Daudeteau gun, that gives the 10 gramme ball with a 22 gramme cartridge a velocity of 750 meters. The ground swept without a back-sight is about 700 meters. At 1,400 meters, the dangerous zone is 22 meters.

With equal weight, the soldier would carry in his cartridge box 160 cartridges of the Daudeteau gun against 80 of the Gras gun and 118 of the 1886 model. He might sweep the ground in front of him to a greater distance and more easily, since the new weapons are lighter and their recoil is more insignificant.

The first condition to be required of this new weapon would be a greater initial velocity. Now the experiments made up to the present teach us that when we exceed the maximum velocity furnished by the 6½ mm. gun we reach pressures in the smaller calibers such that we scarcely dare to continue such experiments. So we think that, in the present state of metallurgy, with the existing powders, and with lead and German silver as materials for projectiles, the caliber of the 6½ mm. is the one that gives the best results.

Is that as much as to say that it is impossible to construct 6 mm. or even 5 mm. guns? Certainly not. The 5 mm. gun exists. Devised by the Austrian manufacturer Kruka and the Swiss professor Hebler, it operates in a satisfactory manner; but it is not a weapon of war, according to the manufacturers themselves. It is a weapon for personal defense for colonists, planters and expedition troops. This gun, which shoots well to short distances, say as far as about 500 meters, could not be used in the wars that are waged between European armies.

The velocity of the 5 mm. projectile is too feeble to allow the dangerous zones to be extended to great distances. Finally, the effects of this very light and fine ball are doubtful. The advantage of such a weapon is its extreme lightness and especially the lightness of its cartridge, which weighs scarcely 10 grammes.

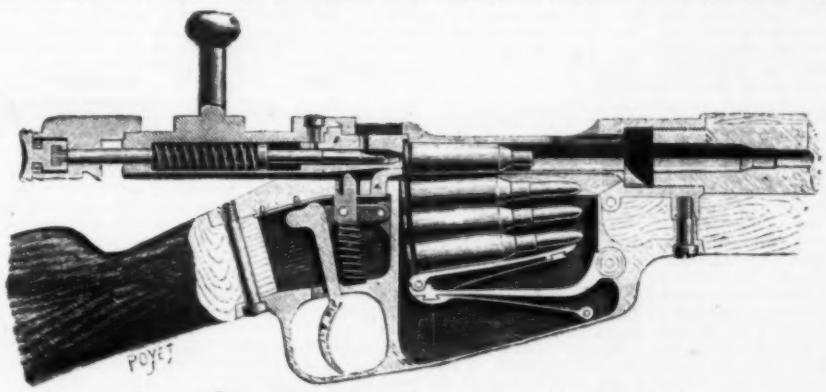
What, then, will be the weapon of the future? A portable gun firing, with an initial velocity of 850 or 900 meters, a projectile that preserves at great distances a sustained trajectory would be for the foot soldier the weapon that is the dream of tacticians.

But, in order to create weapons superior to those just mentioned, it would be necessary to find other powders capable, under a very small volume, of producing the same effects. If a special fulminant placed in the heel of the projectile, or a liquefied or non liquefied gas, permitted of firing projectiles with initial velocities of from 800 to 900 meters, one might then seek the semi-automatic gun of three or five shots spoken of by the *Revue des Sciences Militaires*. Such gun having been found, there would still be reason to ask whether, the human gun carriage not being very stable and being very impressionable, it would not be very dangerous to put this weapon into the hands of troops.

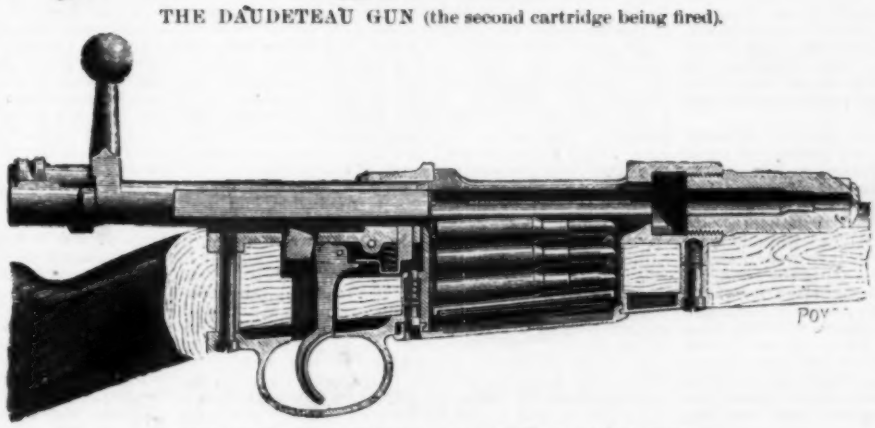
While awaiting the invention of the new explosive, we should congratulate ourselves for possessing at the present time the best of the war powders in existence. It is owing to this powder that the Lebel, which is in the rear as regards repetition, always gives the most rasant and surest fire of all the weapons in service, inclusive of the 6½ mm. guns manufactured in foreign countries.

Briefly, we cannot better conclude than by the statement, reassuring from the standpoint of national defense, that the French gun is superior to all the analogous weapons now in service among the other powers.

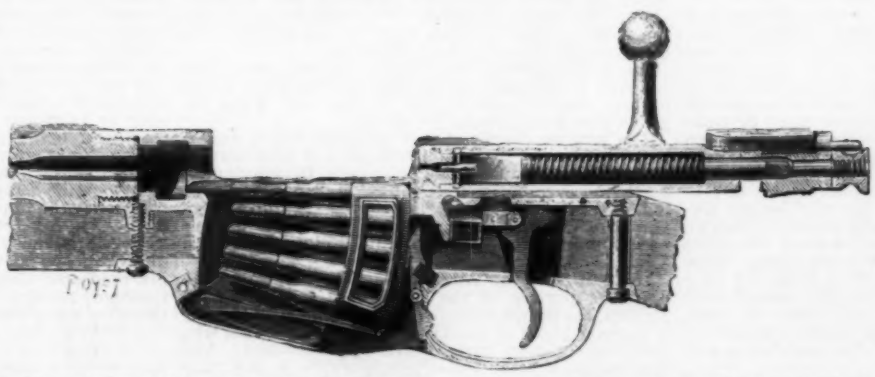
If, by reason of the progress that must always be anticipated, the necessity of a new type should arise, our engineers, we doubt not, would be able to



THE DAUDETEAU GUN (the second cartridge being fired).



THE MAUSER GUN (magazine charged; breech open).



THE MANNLICHER GUN (the loader being introduced into the magazine and the breech open).

give it the most serious ballistic qualities and a mechanism proof against anything. As for the question of caliber, that is, as we have explained, a complex problem. Between the dimensions of the projectile and its effects there exist relations such that it is necessary to maintain a just equilibrium between the various elements, and that it would be impossible to reduce the caliber below a certain limit without causing the ball to lose in force and velocity what it gained in lightness.—*L'Illustration.*

THE AMERICAN OILCLOTH INDUSTRIES.

The following interesting particulars of the rise and progress of oilcloth manufactures in this country are abstracted from a speech recently delivered in the Senate of the United States by Hon. Matthew S. Quay, Senator from Pennsylvania. The address in question not only covers the oilcloth manufactures, but embraces a description of the American carpet industries, together with the materials and machinery employed; it is full of valuable information.

Floor oilcloth, said Mr. Quay, was first made in England in 1804, the originator being one John Buckley, whose principal business in that early day was the painting and ornamenting of vestibules. His artistic work for floors consisted in executing alternate black and white diamonds in imitation of tiles. Noting the inconvenience to his patrons of waiting until the floors were sufficiently dried before they could be used, he conceived the idea of painting his black and white diamonds upon canvas and hanging it up to dry by natural heat. His paints at first were entirely water colors, but as his business increased he saw the necessity of using oil paints, as they were more durable, and of having designs more ornate than the simple diamonds. The patterns were at first produced by stencils, but afterward the engraved or cut blocks were used, substantially as at the present time.

In this way was begun an industry that has grown to respectable proportions, both in England and the United States, about 20,000,000 square yards being the annual production of the latter country at the present time.

The first oilcloth made in this country was made by John Dorsey in 1807, who had his establishment on Chestnut Street, below Twelfth. Isaac Macauley, who purchased Mr. Dorsey's establishment, was really the first man to establish the business on anything like an extended scale. He spun flax and wove it into burlaps for the foundations. Owing to the city spreading out toward Twelfth Street, Mr. Macauley was compelled to transfer his works to what was then called far into the country, the northeast corner of Broad and Filbert Streets, the site on which the Masonic Temple now stands. Later on even this section of the city became too thickly populated and the business proved objectionable to his neighbors. Mr. Macauley in 1814 was compelled to move again, and this time purchased the old Hamilton mansion, standing on Bush Hill, which he supposed to be sufficiently far removed from the built-up portions of the city that the operations would not prove offensive to the citizens.

The specialties made in this factory were floor and table oilcloth, bordered oilcloth covers, all of various widths and lengths, stout, ornamental table mats with a green baize back, medicated oiled silk, highly recommended by the medical fraternity as a cure for rheumatism, and a preparation of the same material made into hat covers, as a precaution from rain, etc. Also carriage curtain coverings on strong Russia duck, with neat figures on the inside as a finish.

In the basement of this factory were fitted up numerous hand looms, on which skillful weavers produced the fabric for the light grades of oilcloth, and the different widths were 4-4, 5-4, and 6-4, suitable for table oilcloth, etc. The preparation of this kind of goods was similar, although on a smaller scale, to that of the floor oilcloth, a description of which will be given below. The foundation for the body of floor oilcloth, which was composed at that time of hemp, and is now known to the trade as "burlap," and imported by them from Dundee, Scotland, was then woven on Macauley's premises, the flax being purchased directly from the Pennsylvania grower.

The raw material was hackled and spun into threads, in what may be called a ropewalk; a number of these threads having been made by a person walking backward the whole length of the walk and spinning them out from a hank of tow wound around his waist, and attached to a wheel which revolved from the strain applied by his backward steps. The threads were then wound on to bobbins, which in turn were inserted into enormous shuttles and driven along the beams of the heavy looms, seven yards wide, by the arms of the stalwart weavers who stood in the center of the loom, and with one powerful stroke sent them whirling from one end of the loom to the other, a distance of 21 feet; and thus the earliest burlaps used in the manufacture of oilcloth in the United States were made at the Bush Hill Oilcloth Factory. The canvas, when finished, being woven in lengths of 60 feet, was removed from the looms and spread upon enormous upright frames, being built contiguous and constructed for the purpose of receiving and manipulating them.

Here, hanging on large tenter hooks and stretched as tight as the strength of the fabric would permit, they received the first preliminary coat of what was called "size" by the application of a composition somewhat after the nature of paste, which when dried filled up all the interstices, and became a foundation on which to lay the different coats of paint or color necessary to form a stout and heavy oilcloth. Then came the priming process, which was effected by applying a light coat of paint with a trowel, the process being similar to that used by a plasterer to-day in coating walls of buildings. When this coat became perfectly dry, it was rubbed down and smoothed from all inequalities, by the friction of pumice stone, or a piece of lava from Italy, or some other volcanic region. Then succeeding each other, and allowing sufficient time only for each one to dry, three additional coats of paint were placed upon the back and two upon the face, which afterward received a coat of choice and selected material called "finishing coat," the goods being now ready for the printer's hands.

The process described was entirely by hand and necessarily slow, as the manufacturer was entirely dependent on natural heat for drying his goods, and where the weather was not propitious weeks often elapsed between the coats as described.

The building in which these cloths were coated was provided with permanent scaffolding, with platforms one above the other, about 6 to 7 feet apart, so that all parts of the canvas could be reached by men standing on these platforms, which were built along the side of the frames, so that by ascending them and working at different altitudes the entire surface could be operated upon.

Having to go through all the processes described, before they were ready to receive impressions of the print blocks forming the pattern a considerable time had passed, and after these prepared sheets of 60 by 21 feet had become sufficiently hardened to permit the handling, they were removed from their frames again and wound around rollers about 22 feet long and hoisted by tackle to the printing rooms, which were in a high, long, hollow brick building on Spring Garden Street. The printing tables extended the entire width of this building with the exception of about 6 feet on each side, in which was built substantial flooring the whole length of the building, and three, four, or five of these platforms, similar to the floors on each story of a dwelling house. The sheet, having been hoisted to the printing room, was placed under the printer's table, with the projecting end of the roller in a notch at each end, and the sheet unrolled until it covered the printing table; it was then secured, and the printer prepared to commence his operations. It had been decided that a pattern containing five colors was to be printed on this sheet. The paints having all been mixed, the tier boy was instructed to put each color in its separate sieve or pad, and to place the block which is to print that color on the sieve containing it. For instance, a part of the pattern is to be printed in red, a red rose, so then the block which the boy has placed upon the sieve or cushion containing the red color has cut upon it a figure of the rose, or any other part of the pattern to be printed in red color; and so on with the other blocks. Each of the other four received the color for its part of the figure.

Now, we will say the pattern he is about to print calls for five colors: Red, green, blue, yellow, and white. The printer takes the blocks with red paint from the boy and proceeds to stain that part of the pattern over the surface of the cloth from one edge to the other, calling the tier boy to replenish the block from the red paint cushion, which it is his duty to keep well covered with fresh paint. Then he asks for the block from the white paint cushion, and impresses, or prints, that part of the pattern in the same manner, and in succession the blocks with the remaining colors, until the whole pattern is formed, or completed; each block being cut so as to fit the spaces left uncovered by the others. Each block is engraved, or cut, for one color, and the portion of the pattern containing the color occupies the same position on the block that it does in the design on the cloth. The sawed lines or cubes are all cut away, excepting those that appear in the portion of the design upon the block. Of course there must be as many blocks as there are colors, and the cost of manufacturing is somewhat regulated by the number of colors used. Some printers use heavy mallets or mauls, and with these they pounded the blocks to make a good impression; but in this particular factory, a lever, or screw press, was arranged running in a groove above the printer's head, which he moved by ropes as he changed his position, and the pressure was produced by means of a handle which projected within easy reach of his hand.

The pattern has now been printed, so far as the impression of one row of blocks is concerned, the entire width of the sheet, and room is required to repeat the operation.

Running from the printing rooms were stout beams the entire length of the building, and on these rested poles, which crossed in front of the printer's tables. There were probably twenty or thirty of them clustered at the far end of the printing room.

All hands were called; the foremost beam was slid along by careful hands on the platform, on each side, and brought forward opposite the table on which the printer was working, where it was lowered to a level with the sheet of cloth, fresh with its first impression. The end of this sheet is firmly tacked to the pole, which is then hoisted just high enough to relieve the table from the printed mark of the goods.

And so the operation goes on, until the whole piece or sheet is completed, and then the inside end was tacked onto another pole, and was swung into the space in the middle of the building, there to hang until sufficiently seasoned to allow of handling. Then it was lowered to the ground floor, where it was rolled up and hoisted onto a rail car on the tramway, and conveyed to an extensive drying floor, which was fenced in and covered a lot of considerable extent in the rear of the factory. Arriving at its proper place, it was unrolled from the car and, being spread out, was left to dry by the action of the sun in the open air until the evening shadows began to fall, when again all hands were called, and the whole force turned out to roll up these sheets, much the same as a crew on a man-of-war is piped to furl sails; and the simile holds good on other occasions, for a threatened thunderstorm brought about the same operation. This was repeated day after day in fair weather, and in foul weather the cloths remained to dry in the building.

When the coat was thoroughly dried or cured it then received a finishing coat of fine, hard varnish, which in turn was allowed to dry in the sun. Then the goods were finally ready for market.

The process described was necessarily slow, and it took quite a year to finish a wide piece of floor oilcloth ready for the consumer. The price of the goods also, under these conditions, was very high, and for that reason the demand limited, as they were entirely beyond the reach of the ordinary consumer, and were used almost entirely in the halls, dining rooms, and kitchens of the well-to-do.

In addition to the American article there was quite a fair proportion of the goods used imported from Britain, the Scotch manufacturers particularly making a popular grade of goods with some consumers who preferred a foreign article to the home product. And this condition and class of people exists to-day, they demanding a foreign article, although no better than the home product. This is not confined to any one trade or class of manufactured goods.

The method of the manufacture of oilcloths, as given, continued until about 1865, when new methods were introduced for sizing and coating the goods, and artificial heat was largely used for drying through the entire process. Narrow widths of goods also came more largely into use. The stuff was more readily handled, the time for finishing shortened, and the price brought down to within the reach of the many. The sizing, the first operation in the manufacture of oilcloth, was particularly slow, uncertain, and unsatisfactory, owing to its entire dependence upon the weather, or Providence, for results; and the thoughts of the manufacturers of this article had been turned for several years to the possibility of getting some simpler, cheaper, and more reliable method. This was finally achieved, and in January, 1871, O. C. Washburn, of Philadelphia, obtained letters patent for drying oilcloth and similar fabrics by exposing them while in continual motion to artificial heat substantially as described.

The burlap was in this manner sized in a continuous length of about 150 yards. It was smoother and much better sized than under the old process. The time was shortened, it was entirely reliable and cheaper, and after being finished the floor oilcloth lay much better on the floor. This improvement in sizing necessitated one of like character in the coating process, and this soon followed. In place of the old system of hanging edgewise in a rack and being coated by a trowel, a series of racks were arranged running lengthwise of the building. They were 90 feet in length and set one over the other at a distance of only 6 or 8 inches, so in an ordinary story, or room, there would be 18 or 20 lengths or pieces of coated burlap, one over the other. These racks were about three yards wide, and a room 30 feet in width would accommodate three of them. The coating machine was placed opposite the first line of these racks. This machine consisted of a strong frame set on wheels, so that it might be moved from one rack, when filled, to the next, and so from rack to rack, until the room was filled with coated goods. A cushion rested between the frames on which the end of the burlap to be coated was placed. A steel knife, or doctor, 2½ yards wide, held in position over the machine by weights, was then lowered until it rested on the face of the burlap about to be coated. Coating color or paint in sufficient quantity was placed behind the knife, or doctor, and after fastening a clamp to the end of the burlap that was already through the machine, and then securing the clamp to a strong rope that ran through the rack from end to end, the preparations for putting on the first coat were completed.

At first the rope which was attached to the goods, together with the coated goods, was pulled through the racks by hand power, but this soon became too slow and too expensive, and belt power was applied, which had the effect of increasing quantity and decreasing cost considerably. This operation was gone over continuously until all the racks in the different lines were filled, taking about ten hours to fill the room, when it was closed, and the heat turned on for the drying process, which, at that time, took from two to four days for each coat, depending on the quality of goods being produced.

At first the drying was done by hot air, either by direct heat from stoves or heaters within the rooms or driven into the rooms from large doghouse heaters situate on the outside of the buildings. This soon gave place, however, to steam heat, a much safer, cheaper, and more reliable system. Coils of ⅞ inch steam pipe were put on the sides of the building the entire length of the racks; also lines between the racks, sufficient radiation being put in to get a degree of heat, if necessary, of 150° to 165° F. This method of drying is that in use to-day in the majority of the oilcloth factories in the United States. Coat after coat is put on in the manner described until the goods are finished and ready for printing.

In the coating color, or composition, there has been considerable advance made, all good manufacturers aiming to produce a more pliable, elastic, and better finished piece of goods, at a less price than his competitor. In this way the consumer shares very largely the benefits from improved machinery and processes, and at a lessened price gets better goods, better value, and improved appearance year by year. The manufacturer gets a larger output, and correspondingly lesser profits.

One of the principal improvements in composition, or coating color, was the invention of Mr. Thomas Potter, of Philadelphia, who, on December 6, 1877, was granted letters patent for "Improvement in processes for making oilcloth," which consists in sizing, filling, rubbing, and drying the foundation web of jute, in the usual manner, coating the web so prepared with an impervious varnish, printing the pattern direct upon said varnish when dry, and after the drying of the pattern superficially varnishing the whole, substantially as and for the reasons specified.

This invention was a long stride in the direction of a bright, elastic, and waterproof face, or finish, for floor oilcloths, and led to other improvements in that direction, of more or less importance.

After each coat in the operation was dried, it was necessary to rub it down smooth, or pumice it. This, as stated, was formerly done by hand entirely and was a process much too slow to keep pace with the comparatively rapid processes of sizing and coating, and cost out of proportion to the other processes.

It was reserved for Philadelphia again to solve the problem of a rapid and labor-saving machine for rubbing or pumicing the oilcloth, Augustus E. Snow, of that city, being granted a patent on July 1, 1873, for the combination, with an oscillating rubber provided with a pumice stone-coated rubbing face, of one or more metallic scrapers attached to said rubber.

Thus far the improvements in the manufacturing up to the printing process have been completed, and considerable advance had already been made in that direction, one McClinch, of Hallowell, Me., having invented and assigned to Alden Sampson & Sons an improved press, or power printer. It was a flat block machine, and although it never did satisfactory work, and could not compare in results with good hand work, yet it turned out a very much larger quantity of goods than could be turned out by the hand method, probably doing the work of twenty-five or thirty men.

Numbers of other patents were got out on different principles, but all of them fell short of entire success.

Finally, in 1869, the first perfected rapid printer, flat surface machine was completed, and a number are running and in good order and doing satisfactory work to-day. This machine, under certain conditions, will do the work of 75 to 100 men, and do it in an eminently satisfactory manner, quite equal to the best hand-printed work. Other excellent machines have since been produced.

This part of the process having been brought to perfection, leaves only the varnishing or finishing process to be accounted for. In the early process the goods were spread on a platform in the open air and always on a clear, bright day, and the varnisher spread the liquid on the face of the sheet of cloth with a large, flat brush, somewhat similar to an ordinary whitewash brush, crossing and recrossing the entire width of the goods until the surface had been covered. After this operation the goods were left in the sunlight for several hours, or until the face hardened.

The present mode of varnishing by machinery was adopted on or about the year 1884. The machine in appearance resembles somewhat the coating machine, only in place of the knife or doctor, a composition roller is substituted for spreading the varnish evenly on the face of the oilcloth, and is quite as rapid and labor-saving in its work as the other machine, and has added its full quota toward the production of a cheap oilcloth, so desirable from its bright and attractive appearance, either in the home of the rich or the poor. Bringing the price of these goods down year by year to within the reach of all had the effect of largely increasing the demand, and in 1880 the factories of the United States were supposed to have produced 8,000,000 yards of oilcloth—narrow oilcloth—under 2½ yards wide. During the year 1885, five years later, the output had increased to over 10,000,000 square yards, and the production increased annually, so that in 1892 the output could not have been less than 20,000,000 square yards, showing quite a rapid growth of the business and evident benefit to the consumer of this class of goods.

The oilcloth business extends into several leading branches with special description of makes and qualities, the buyers of which are found respectively among carpet and dry good houses, carriage makers and upholsterers.

Table oilcloth, another branch of the business, and goods of an entirely different character and construction, are sold almost entirely by the jobbing dry goods and notion houses. Formerly these goods were all made with a black face, on which was printed by hand block (the process being very similar to that already described in floor oilcloth) patterns in fancy colors and small geometrical figures, and trails were largely used, but owing to the fact that there was but one face color, black, the variety in appearance was limited. About 1855 England commenced the manufacture of extremely fine and flexible oilcloths, in a variety of ground or face colors. They were chiefly imitations of valuable woods, such as mahogany, rosewood, teak, oak, etc., and in this line the American manufacturer followed. All these goods were produced, arranged, printed, or ornamented by hand, and the product was a decidedly limited one. In 1870, however, a new departure was taken. Machinery for ornamenting the face, or putting on the pattern, was introduced, and beautiful effects, imitations of inlaid mosaics and brocatelles, were engraved on copper rolls and transferred from them to the face of the oilcloth. The output was very largely increased to meet the steadily growing demand owing to the improved styles and more desirable nature of the fabric, compared with the former product. The price also was materially lessened, and this helped to popularize the goods and make them what they are to-day, a leader in almost every dry goods and notion store in this country, and bringing the business up from less than 1,000,000 yards in 1870 to probably over 10,000,000 in 1892.

The foundation of these goods is of sheeting made from middling uplands cotton, the fabric weighing about three and a third pounds to the yard. These sheetings were formerly made entirely in the Eastern States, but for the past few years the Southern mills are rapidly pushing their Eastern competitors to the wall. They produce quite as good a fabric, and appear to be able to do it at a little less money. Very much everything in the makeup of these goods is American—the cotton from the South, the linseed oil from the West, the clay from Virginia, the turpentine from Georgia, colors from New York and Pennsylvania, and the labor is American and all adult. The progress in the business for the past ten years has been in the direction of producing more elastic material, greater variety of patterns, and generally more attractive goods, and that at a steadily decreasing cost. The foreigner has the advantage over the American manufacturer, in having cheaper foundations. Eastern cotton, though a shorter staple, and by no means as desirable for the majority of purposes, in this case answers very well. It is not as strong, will not be as serviceable, but makes the price for the better article. Labor also in this class of goods, as well as for oilcloth, is very much against this country. We pay at least 100 per cent. more in this country than they do on the other side.

There is still another class of goods, called "enameled oilcloth," or "leather cloths," manufactured in this industry. These goods were first made in England; afterward in this country, and have been more recently taken up in Germany. The demand for this class of stuff comes largely from the carriage maker, who uses it for cheap work in place of leather. It is also used by railroad companies for seat covering in emigrant cars and locomotive cabs, on account of its cheapness and durability. It is made in many weights, widths and qualities; the cheapest or lightest weight being made on a light muslin sheeting. This article is largely used by bag and satchel manufacturers for cheap work in that line. The other weights are made on drilling and ducks, all cotton. A large portion of them are made in the Southern States, and help to add to the prosperity of that section. The process of manufacture is almost similar to that of table oilcloths, up to the finishing face, which, after being varnished and dried, is put through an enameling or embossing machine, which consists of a steel roller, on whose surface has been cut imitation of leather grains, such as goat skin. This roller works against a paper bowl, which, having been thoroughly dampened, has taken the impression off the steel rollers, thus forming a die. Between these rollers or bowls the goods are placed, pressure is put on, the machine started, and the grain or pattern on the rollers is transferred to the face of the article.

The same class of goods of different colors is made for the upholstery business, for covering lounges, etc., and takes the place, for cheap work, of the fancy-colored leather usually used for that purpose, which is a very high-priced article and can only be used on fine work and to trade that can afford to pay large prices. The oilcloth imitation of leather gives quite as good an appearance; is soft, pliable and elastic, and will give full satisfaction in wear, considering the amount invested, which cannot be more than one-fifth of the more expensive article. The same can also be said in regard to black goods that go into wagon work and have helped materially in the production of the cheap American buggy, covering top, bows and seats, making a cheap and desirable substitute for enameled leather and adding to the comfort, convenience and pleasure of the thousands of users of this very popular wagon.

We now come to the last, but by no means the least, of the productions of this industry, viz., linoleum. This article has, during the past few years, become quite a popular floor covering both in Europe and in America. It also is a native of Britain, having been invented and patented by one Walton in 1868. His claims are fully set forth in patent bearing date of that year. The ingredients used in the manufacture of linoleum are linseed oil, ground cork, gum, resin, Peruvian ocher, red lead, litharge, chromes and burlap as a foundation.

To prepare the oil, it is heated to quite a high temperature in large kettles or receptacles, suitable driers being added, and the oil is oxidized either by prolonged boiling and the injection of air or by exposure of the oil in films on cotton or scrimp, in a large building constructed for this purpose. The latter process is by far the slower, although the results give a better quality of oil. The sheds or buildings for this purpose are provided with racks, so that the cotton can be hung from battings at the top of the building. The heated oil is pumped to the top, and is scattered or spread by a fan all over the cotton or scrimp. This becomes thoroughly saturated, and the building is kept heated so that the oil dries. A considerable portion of the oil runs off this cotton to the floor, and this is drained to a well and repumped to the top and again sprayed over the cotton. This process is known as "flooding," and is continued every day until the "skins" are thick enough to use. This process of oxidizing requires from three to four months to get the oil into proper condition. When this has been accomplished the skins are cut down and carried or taken to the mixing room.

Cork is very largely used in this business, being one of the principal raw materials in bulk. It comes to the linoleum manufacturer in large pieces from the cork cutters. It has to be reduced to small pieces by a machine called a "breaker," consisting of pairs of toothed rollers of coarse and fine pitch; one of the furnishing rollers is fitted with an adjustable concave. The cork leaves the machine in pieces of about one-fourth of an inch to three-eighths of an inch in diameter. The granulated cork is conveyed by screw conveyor to the top of the mill, where it is dumped into hoppers leading to the grinding stones. These stones are usually made of picked French burr. They must be without a flaw and of a proper density and hardness. They are built on edge, cemented solidly together, and when finished the stone measures about 4 feet 6 inches in diameter by 15 inches thick. The top stone is usually the runner. Extreme care is necessary in grinding cork, as the dust is very light and inflammable, and steel or any foreign matter passing through the stone will often cause a fire. The ground cork is now conveyed by screw conveyors to the bolting or dressing machines. The cylinders of these machines are covered with a fine gauze wire, and the cork is forced through by revolving brushes. The cork that goes through these fine perforations is the proper fineness, and ready for use in the mixing room. The remainder is reconveyed to the stone and ground over.

Linoleum is backed or coated on the back before the preparation on the face is put on. This is done by preparing the outer side of the burlap by sizing an application of a coat of paint. It is done by a machine very similar to that used in the manufacture of floor oilcloth, and the coating or operation requires several days to dry before going on with the additional process. Having now our principal raw materials ready, the next operation is preparing the cement or composition thoroughly on the burlaps. The cement is first made; that is, the mixing of the oxidized oil with colors, gums and resins. The ingredients are heated together until they are in a plastic condition. It is then allowed to cool, and is cut into batches of certain weight. The cement is a tough, rubber-looking mass. Pieces of cement are now fed into a machine called a "German mixer." This is a very elaborate machine fitted with hard knives on a steel shaft, which revolve between stationary knives. The knives are fitted in screw fashion. The oil is fed in first, then a certain quantity of prepared cork is fed in, the knives disintegrating the oil and the cork dust becomes thoroughly incorporated with the oil. The composition is forced out of the "German" by the screw action of the knives, and is conveyed to machines called "roller mixers." They may have one or more pairs of rollers running inwardly at different speeds. One of the rollers is kept cold and has a knife or "doctor" fitted to it for the purpose of scraping off the adhering composition. The material is passed through several times and from one mixer to another, and is finally passed through a "scratcher." This is a mixer having a spiked roller revolving at a high rate of speed, and this tears the composition into very small pieces or crumbs. The scratched material thus described is then conveyed to the calender.

The calender is a very heavy machine and has two pairs of chilled iron rollers. The first pair measure 84 inches long for a 2-yard machine, and 150 inches long for a 4-yard machine, are 30 and 36 inches in diameter. The other pair are the same in length, but smaller in diameter, and are for "finishing" or cleaning the face. The rollers are bored for steam, as it is necessary to have them hot in the process. The smaller rolls weigh about 10 tons, and the larger rolls weigh fully 20 tons each.

The backed or coated burlap is now laid between the rolls above described, and the composition from the mixing room is spread on it behind the rollers, which have pressure put upon them according to the grade or gauge it is desired to produce. The thinner or cheaper grades take the largest amount of pressure.

When the material leaves the calender it is conducted into a heater or curing room, a very high, hollow building, fitted with racks, and the cloth is hung up in folds to dry. This drying and seasoning process takes from one to three months, depending on the grade of goods.

When cured the cloth is taken down and spread out upon the floor, and is lined out and prepared for the printer. These goods are mostly printed by hand, except some few of the very cheapest grades. The process of printing by hand blocks was described and does not need any detailed description. It is a very costly part in the manufacture of linoleum. The preparation of designs and blocks is quite an art in itself, and high-priced, skilled labor is required, and great expense is entailed in preparing suitable blocks for the work. There is, on the average, six or seven blocks to the pattern, and two men will print from 50 to 75 square yards of linoleum per day, depending largely on the pattern and quality of goods produced.

The printing color, while apparently the same as that used on floor oilcloth, is an entirely different mixture. The pigment is the same, but in addition to the oil, varnish is introduced into the body of the print used on linoleum to give it the necessary gloss, as the goods cannot be varnished later on in the process.

When the cloth leaves the printing table it is drawn into heaters to be cured and hardened. This process takes from four to eight weeks. When the goods are thoroughly cured, the cloth is taken from the heater to the trimming and packing room, where each piece is laid out on long tables and trimmed by hand, with a straight edge, and carefully inspected. When this is done the goods are packed and ready for shipping.

This fully describes the past and present process of the manufacture of this deservedly popular floor covering known as linoleum. It has many good qualities; it is noiseless, sanitary and durable. Where it is used plain, that is, without having a pattern printed upon the surface, it will wear and preserve its appearance for many years.

TECHNICAL EDUCATION.*

By LOUIS SPENCER LEVY.

NOTHING in the entire history of civilization is more interesting than that which deals with the theory and practice of education.

In the educational theory of an age we find the fruits of its great minds; in the educational practice, the essence of its labors.

The school is the only point at which a generation meets its successor systematically and with a definite purpose in view, and to the attainment of this purpose, the preparation of the rising generation to take its place in life, it brings all its best energies and its ripest experience.

In educational practice, the last steps makes the next possible; so we advance from good to better, and from better to the best system, which is that of technical education.

From its very name, technical education signifies a training in the elementary principles of several trades. It does not teach the pupil to become a thorough mechanician, nor does it give a full knowledge of the use of the tools, but it instills into him a higher respect for the dignity of labor and the principles of the trade; it assumes a rudimentary education and builds upon it as a foundation.

To the mechanic, the shop of the technical school which his son attends is but a play shop. He acquired his own varied education there and affords an instance of the efficacy of such education.

While it is true that a pupil who has received a technical education will be better fitted to act as a carpenter, or a draughtsman, or a metal worker, than he who has not received the benefit of that education, it is also true that he will make a better lawyer or a better physician, and all for the reason that he is a more thoroughly educated man than his fellow in whose preparation technical education did not enter. Thus it is in accord with the principle of ideal education.

It follows that the lawyer or physician who has received a technical training, though he may not have followed any of its branches in the mechanical arts, has been taught the great lesson of the application of theory.

His previous training guides him in most cases and conditions, which, to another, would seem perplexing, and he easily finds a solution of the difficulty.

To the practical scientist or mechanic who has received the varied training which technical education affords, "hard times" are not so apt to come as to others.

Impeded in one pursuit, he turns immediately to another, in order to bridge over any period of financial depression.

The question, however, may arise, "Would the pupil not have acquired a better knowledge of the trade which he is to pursue by serving an apprenticeship rather than by attending a technical school?" To this we answer that the object of technical education is not to teach a trade, but to give the pupil a varied knowledge, and to find out for what trade or profession the pupil is best fitted.

What the world requires is men of broad intellect. A lawyer was engaged to defend a client whose case had not a very bright outlook, but by recourse to his technical knowledge, he showed the arguments of his opponent to be incorrect, and won the cause. Such instances are not uncommon.

The difficulty encountered in the introduction of technical schools, as such changes in education do not take place overnight, is the abrupt termination of the education of those pupils who are compelled at an

* Prize essay delivered at the commencement of the Hebrew Technical School, New York City, June 14, 1894.

early age to enter the world's great list of bread winners.

Technical education should not only be taught to those who may have the good fortune of better circumstances, but to be made a popular and national education is its great aim.

Still, with all these strong arguments, there seems to be a decided hesitation in the popular mind with regard to the desirability of such a system.

The only reason that can be assigned is the prevalent antipathy to oily hands and heated brows.

The arguments brought in favor of technical education apply so thoroughly to the ideal view of popular education that its advocacy would affect the present school system to such an extent as to revolutionize all methods now employed.

While laboring for the ultimate triumph of technical education, we must be gradually improving the present order of things, and work for the strengthening of our educational theories, to prove to the world the actual, if not apparent, value of that system which but a short time ago was founded.

That we endeavor to promote all projects in its behalf is the appeal of those in whose care the future welfare of education rests.

SMULDERS' SUCTION DREDGER.

THE use of sand pumps for the deepening of ports and keeping them in order offers great advantages in all cases in which one has to do with very homogeneous material, such as sand, gravel or mud.

The experiments made in the work on the Amsterdam canal permitted of ascertaining that the saving effected through the use of the pump over that of the bucket dredger is 0·02 of a franc per meter of spoil removed. Still more remarkable results were observed at the time of the deepening of the port of Saint Nazaire.

It is therefore not surprising to see contractors give preference to these machines when the conditions of the work are such as those just indicated.

It was for this reason that the Russian government two years ago ordered of Mr. A. F. Smulders, of Utrecht, two apparatus with sand pumps designed for the ports of Liban and Cronstadt, and capable of operating to a depth of 33½ ft. beneath the surface of the water.

The principal dimensions of the boats are as follows:

Length upon the deck	141 ft.
" between perpendiculars	137 "
Width amidships	26·5 "
Depth "	12 "
Draught	11·5 "
Capacity of the hopper	11,000 cu. ft.

The hull of soft steel; the engine and the boilers were constructed under the surveillance of the Bureau Veritas, which made the first bid for them.

The apparatus comprises a suction pump capable of extracting material from a depth of 33½ ft. under water, at the rate of 11,500 cu. ft. per hour, although the result has been obtained in a much shorter space of time. This pump is directly actuated by a 350 horse power compound vertical engine, with surface condensation and change of direction, and the principal dimensions of which are as follows:

Diameter of high pressure cylinder	20 in.
" " low " "	39 "
Common stroke of pistons	22 "
Number of revolutions per minute	140

The cylinders are jacketed and have automatic blow-off cocks.

The surface condenser is provided with tinned brass tubes.

The feed pump is double acting and the air pump single acting, and actuated by the crosshead of the pistons through the intermedium of connecting rods and working beams. The engine likewise actuates the propeller of the boat directly, and the couplings are screw and fly wheel ones.

The steam is furnished by two boilers constructed of Siemens-Martin soft steel, and registered at six atmospheres. Each of them has a heating surface of 160 square feet.

The boilers are fed through a pump actuated directly by the engine, as well as through two steam donkey pumps and two injectors.

A hand pump with different plungers serves for tests by hydraulic pressure.

Near the boilers there are two coal bunkers having a capacity in common of 25 tons of coal.

The hopper containing the dredged material is fifty feet in length and carries in the center, in the direction of its length, a keelson in which the 16 doors of the bottom join. These doors are maneuvered by means of steam windlasses and spare hand windlass.

The suction pipe of the pump has a diameter of 24 in. and a length of 49 ft. At the end that plunges into the bottom it is provided with a steel grating to prevent the introduction into the pump chamber of stones or other objects of too large a size.

A special apparatus is fixed to this pipe in order to disintegrate the trunks of trees, etc., that likewise might be sucked in by the pump.

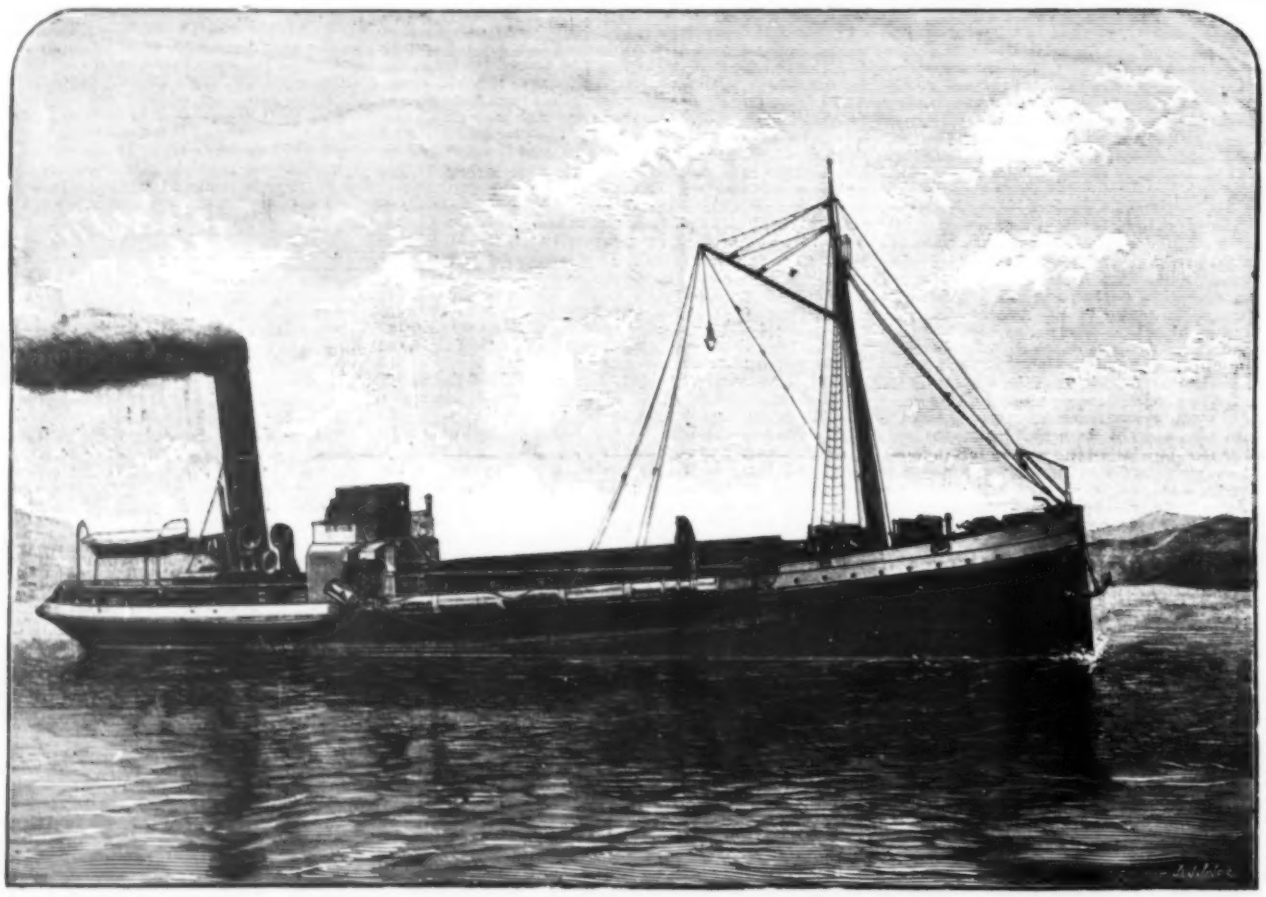
The suction pipe is movable at its point of junction, and can, therefore, be lifted entirely out of water when the boat is to sail in order to deposit the spoil at sea. For this reason, the speed of the boat is relatively greater for the same power developed with the engine. The speed under a load, with the suction pipe lifted out of the water, is about 7½ knots.

The lifting of the pipe is effected through a special double cylinder engine, and through the intermedium of pulley blocks and cables. The front of the pipe is lifted by the windlass of the bow anchor arranged to this effect. The rudder is actuated by a hand windlass arranged in a pilot house placed upon the deck over the engine room.

The captain has at his disposal a bell telegraph that communicates with the engine room.

The boat is provided with masts and rigging. The installations on board are quite luxurious, and consist principally of a saloon for the captain, of a saloon and office for the engineer, of a dining room, of cabins for the mechanicians, and of kitchens and apartments for the crew

Upon the deck there are lifeboats and buoys, and the whole is lighted by electricity furnished by a special engine. The cabins, etc., are heated by steam, and the heating apparatus is provided with pressure reducers that may be regulated at will.—*La Revue Technique.*



SMULDERS' SUCTION DREDGER.

THE CATASTROPHE AT LIMA, MONTANA.

By J. M. GOODWIN.

THE sudden emptyings of reservoirs in Idaho and Montana lately should teach some very important lessons, if the facts and conditions are properly studied and heeded. It has been shown that the flood in Idaho, in March last, by the breaking of the dam, came from inferior construction with unfit materials, and in which case the dam was washed out. In early May a very different problem was presented in the case of the emptying of the reservoir belonging to the Lima, Montana, company, where the dam was left intact. While the flood was quite disastrous in covering lands with debris, washing away of soil from fields and flooding lands and buildings, the losses from these causes alone were not very great. The valleys of Red Rock and Beaverhead were wide enough to permit the water to spread out and hold back the torrents to such an extent as to make the progress of the flood downstream very slow. It is doubtful if there is a more enticing place in all the country for throwing a dam across a stream to secure a great storage reservoir than was the one selected by the company that put in the dam twelve miles above Lima. It was in a deep, narrow canyon, requiring a short dam and which was easily constructed with material on each side. On the left hand side the hill rose abruptly from the water, and it was a solid mass of conglomerate held by Nature's own and best cement. On the opposite side the hill was made up of gravel, bowlders, sand, etc., much stratified, being all secondary deposit, or "wash," and of ample strength to hold back the water in the reservoir, had it not been unwisely cut. While that was really the weak point in structure, it would have stood more than the pressure alone, and which did not cause its destruction, as will be shown later. These hill sides hedging in the stream were covered with brush, all of which was rooted out and burned, leaving the surfaces in good condition for putting in the earth and stone work of the dam. At the bottom of the stream the space between walls was only fifty feet, while forty feet up it was 110 feet. A trench fourteen feet wide and fourteen feet deep was sunk clear across this space of fifty feet and masonry of stone and Portland cement put in, having sixteen feet base and tapering to six feet at the top, a point ten feet below the top of the dam. This wall was bounded with the hill on each side and formed the core of the dam, the main structure being earthwork. Transversely the dam had a base 300 feet wide, while the center on top was forty feet wide, the two slopes having a rise of one foot in two and a half feet horizontally. These slopes were well protected by a covering of stone eighteen inches thick.

The discharge into the canal system to be inaugurated hereafter was through a tunnel 7 × 7 feet and 176 feet long, cut through very hard conglomerate, making the cutting of it very difficult and expensive. This conglomerate had fissures in it, and these in connection with a body of dolomite, which swelled badly in getting wet, caused a little caving inside of the tunnel and throwing down some obstructions to the free flow of water. The tunnel should have been lined inside, to make it secure and give free flow of water. This tunnel had a capacity of 1,500 cubic feet of water per minute under the proposed pressure in the reservoir.

The company selected the right hand side, some distance from the dam, for a spillway to carry off surplus water to keep it down to a safe level. That appears to have been simply an open cut in the ground, all of which was secondary deposit, and to have been an insecure affair should any great body of water run through. Citizens in the valleys below became afraid the dam would wash out and serious losses follow. Such a hubbub was raised over the dam and what they deemed impending danger, which were so thoroughly talked over as to excite citizens, that an agreement was finally entered into by which a few citizens and the county of Beaverhead were to contribute enough to put in a new and larger spillway. Only

two of the board of directors were residents of the State, and they for their part agreed for the work to be done and to waive all claims for damages they might sustain. This new spillway was to be some distance farther in the hill, and to be cut to a certain depth, thirty feet wide at the bottom, and with a grade of one per cent. and it required a cutting about 350 feet long. The work was done by a contractor under the guidance of J. H. Haines, sheriff of Madison County, the dam being in that county. Mr. Haines was not an interested party, further than to carry out the wishes of the people. He was not a civil engineer, and pleaded ignorance of hydraulics, but he did the best he knew how, and no one blames him in the least for what afterward happened.

It is safe to say no good hydraulic engineer would ever have constructed a waste weir as this one was. The earth to be cut through was made up entirely with secondary deposit, and this was in layers in succession of hardpan or cemented gravel, sand, bowlders, etc. These layers had a dip upstream of seven to ten degrees, while the cut was to have its bottom pitch the other way one per cent. Necessarily with this grade and the head high up made a fall of thirty to forty feet at its lower end or discharge, enough to rapidly tear away the earth and make the plunge work upstream at a greater or less speed. Had some of the streaks of hardpan pitched the other way and been used for the bottom of this spillway, it might have carried a stream indefinitely. But its weak point was in having the underlying strata dissolved and washed away, leaving the streaks of hardpan to fall from pressure and lack of support below section after section, until it had washed clear back to the water, and thus emptied the reservoir with a great rush of waters. Nature has recorded in its history of rocks the fact that Niagara Falls has gone upstream many miles through the waters in the big plunge, softening and washing out the softer materials beneath the rocks, leaving them to gradually split off and fall from their own weight and that of the water running over them, then to be pulped by the "mills of the gods" and carried away.

In the Lima dam we have the spectacle of that structure as firm as ever, while off to the right is a chasm 150 feet wide, 50 feet deep and 500 or 600 feet long, from which the floods carried out from 1,500,000 to 2,000,000 cubic feet of earth, the bowlders, gravel and heavier portions finding lodgment below, while all there has been greatly changed in appearance.

The beautiful grassy bottom of a few hundred acres a few weeks ago is now ruined, while the creek flows in two streams, one each side, instead of in the old channel now filled up.

If, in construction, a good headgate of masonry had been put in, and a solid flume for the surplus water to run through clear down to the creek level, there would have been no washout and no flood, and the company would not now have a chasm more difficult to dam than was the one now standing firm.

This dam was intended to hold back and reservoir the rainfall of a drainage basin 100 miles long by 80 miles wide. The reservoir was filled to within eight feet of the top of the dam when the waters broke loose and it extended upstream about fifteen miles, averaging one mile wide. What the plans of the company are for the future is not known. Where the responsibility for this flood and resulting damages rests is likely to be determined in the courts. Certainly there are rights in equity which will be contested for, and which the writer does not care to discuss. If it results in a failure of the irrigation enterprise to cover the beautiful valleys below, it will be bad. But the lesson it has given should prompt such State laws as will forever prevent as far as possible the recurrence of any similar future catastrophe. This company capitalized at $500,000, incorporated under the laws of Montana, and it is time there should be laws governing and controlling such enterprises to at least the point of safety to the people, as well as defining rights in equity for both the people and companies, and such laws should embrace the services for the State of one or more competent hydraulic engineers.—*Irrigation Age.*

THE DRAINING OF THE ZUIDER ZEE.

PROBABLY Europe will soon be slightly enlarged, for there is talk of adding a whole province to the Netherlands by draining the Zuider Zee. Fifty years ago there were plans for doing this on a very large scale, bringing the islands of Texel, Vlieland, Ter Schelling and Ameland inside of the dikes, by connecting them with each other and with the main land by dams. But the plan fell through chiefly on account of the great strength of the currents encountered.

Lately the Zuider Zee Company, under the direction of Engineer Lely, have been working earnestly on this matter, and through the influence of Lely a commission was appointed to investigate the Zuider Zee question. It went to work energetically, and soon handed in a report containing much excellent material for the practical solution of the great problem. The commission recommended, as the Zuider Zee Company had done, the closing of the Zuider Zee by means of a dam that would connect the little island of Wieringen with Helder on the west, and with the coast of Friesland, near the village of Piaam, on the east. This plan would also fulfill the requirements of the Land Defense bill. The harbors of Nieuwediep and Harlingen will not be injured, nor will the water supply for North Holland or Amsterdam be interfered with. In the middle of the region to be drained a portion of the surface will be left open under the name of Yssel Lake. To be sure, the fishing in the Zuider Zee will be somewhat interfered with during the first work on the dams, and later it will be stopped entirely, but the commission proposes to indemnify the fishermen by guaranteeing a pension to the old men and placing at the disposal of others boats suitable for fishing in the North Sea. The laying out of the fortifications at Amsterdam would require enlargement of the system of forts and an increase of the garrison. The danger to the inhabitants during the draining of the swampy land from malaria and other diseases will be kept at a minimum by the strictest observance of the laws of hygiene. The whole undertaking will require nine years, and will cost about $72,000,000, including the cost of the fortifications and the reimbursing of the fishermen.

By draining the Zuider Zee 469,490 acres of excellent marsh land will be gained, so that the financial success of the undertaking may be considered a certainty. But far more important than the direct profit are the indirect advantages to be gained by the accession of such an extent of land suitable for agriculture. It is true that a reduction in the price of land and an increase of wages in other parts of the Netherlands is to be feared, but only for a short time; and on the other hand, work will be provided for many of the unemployed.

The majority of the commission (twenty-one members) favor the method of draining described above, while seven members maintain that the work cannot be economically and successfully carried out in this way. But all agree that if the work is undertaken, it must be done by the government, so as to exclude speculation from the scheme.

Holland has already been very successful with other work of a similar nature although not so extensive; we refer to the draining of the Haarlem Lake and the connection of Amsterdam with the sea by means of a canal.—*Illustrirte Zeitung.*

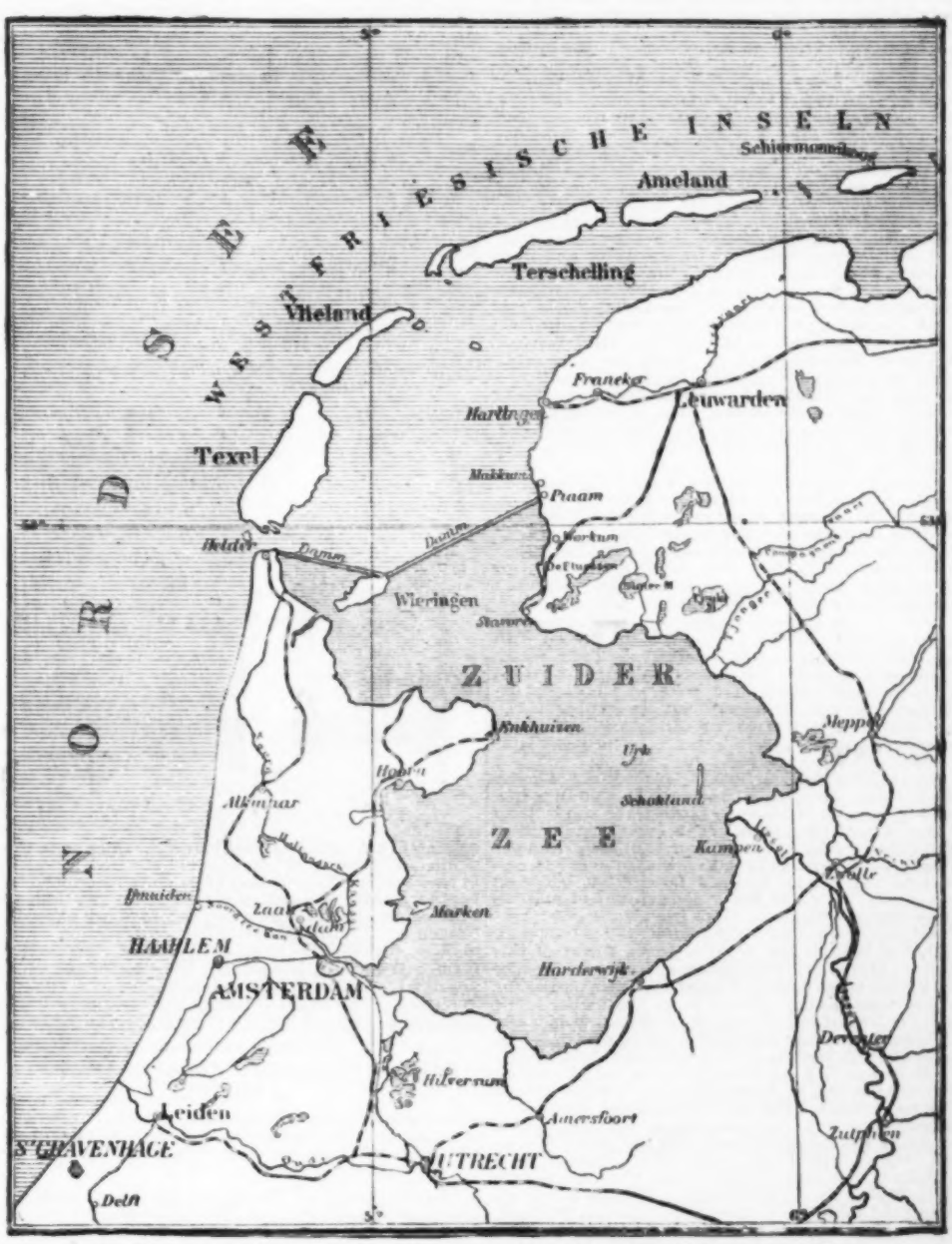
THE ZUIDER ZEE.

EVER since the successful drainage of the Sea of Haarlem, it has been a rooted idea with our neighbors in Holland that the Zuider Zee itself might be subdued by the much improved and far greater resources of science now in the hands of hydraulic engineers; for, as the hateful cancer absorbs the life of the human body, so does this far-spreading lagoon threaten the very existence of Holland. Thus, for many generations, the question of draining the Zuider or "south sea"—so called by the Dutch in contradistinction to the much greater North Sea—has never been permitted to rest in the minds of the people, and especially since the cutting of the Helder Ship Canal the matter has occupied the serious attention of the Dutch government, to whom more than one proposal was made by French engineers upward of fifty years ago. In 1865 a Dutch Credit Foncier Association took up the scheme, and employed the engineers who had successfully drained the Haarlem to report on it. A series of soundings and a thorough investigation showed clearly that four-fifths of the bottom of the Zee was composed of valuable alluvial clays and fine loam most suitable for the highest cultivation. This occupied the officers of the company for the space of two years, when a commission of specialists was appointed to report further on the matter and to decide upon plans for carrying it into execution. In 1873 an official report of voluminous extent declared the project possible, and, moreover, if carried out, an enterprise which would confer great benefits on the country. The experts recommended the granting of a concession to the Credit Foncier, in the event of that body proposing clear and definite plans.

Whatever those plans were, the enterprise appeared so vast and so liable to failure that nothing came of the scheme till about 1886, when the "Zuider Zee Company" was formed, whose "statutes of association" were duly welcomed and approved of by a royal decree. Notwithstanding, the Dutch government hesitated to launch itself into a project of such limitless scope before another royal commission, sitting at the Hague, had given it some further years of consideration, and it is this body which has but recently concluded its labors and recommended, by a majority of 21 to 5, that the drainage of the Zee should forthwith be attempted.

Four hundred and fifty thousand acres—or enough land to make 2,500 extensive farms—it is proposed to reclaim, at a cost estimated in English money at from fifteen to sixteen millions sterling, or with accumulated expenditure, including measures of defense and compensation to the fishermen of the Zee, at not less than £25,300,000.

This is clearly a very large speculative expenditure for a not very rich country like Holland, but there are few people who will not be ready to agree that the money so spent will be put to a much better purpose than sinking the same amount on an army or on an iron-clad navy, in the case of Holland. The value of the land reclaimed is computed at £26,100,000, and thus in thirty-two years—for that is actually the time allowed for completing the work—Holland will not only have added a fertile province to her territory, but will be in a position to make a profit of not less than a million sterling out of the transaction. It is a bold scheme, and there are few people who will not cordially hope that its bold but wary projectors may be eminently successful. The drainage is to be carried out by means of channels leading down into Friesland, after a substantial dam has been constructed across the sea from the island of Wieringen east and west to the main land; and there are reasons for believing that this stupendous work will be undertaken by the state. Though old in one sense, the Zuider is still the youngest sea in Europe, for previous to the year A. D. 1219 the whole area extending from the Texel, Vlieland, and Schelling south to Naarden, was either dry land, forest, or marsh, with the exception of Lake Flevo, which was drained by the river Yssel, not then, as now, an arm of the Rhine. About B. C. 12 the Roman general Claudius Drusus cut a canal from the



MAP OF THE ZUIDER ZEE, IN THE NETHERLANDS.

Rhine to the Yssel, and chiefly owing to this, as some assert, the lake overflowed its banks and commenced to submerge the low lying adjacent lands. In A. D. 1219, after a continued stress of northwest gales, the furious topping waves of the North Sea broke down the dikes reaching from the Texel to Schelling, when a great portion of the country, lying from twelve to fifteen feet below the level of the ocean, was inundated. These ravages continued more or less every winter, and so went on swallowing up the low land till the year 1282, when the last great inundation took place, and gave to the Zuider Zee the form and depth which it still preserves. About the same period inundations occurred on the low sandy shores of the Schelkt and the Meuse, by which Holland lost to the devouring sea some 300 square miles of valuable land. At the present time, and for years back, the Zee—from which Vanderdecken sailed in his "phantom ship," and from which Tasman also departed on his historic voyage to New Zealand and Tasmania—is almost useless for purposes of navigation, for an inspection of the Admiralty chart shows that its deepest navigable water is not more than 17 feet at low tide, or 21 feet at the highest. Pits and channels there are south of 53, with as much as 27 feet, but for general purposes of navigation the Zee is nothing more than a shallow bay, totally unnavigable for any but the smallest craft. South of Marken Island, and for a distance of forty miles eastward of Amsterdam, there are stretches of shallow water, with no greater depth than from 7 to 9 feet at low water. On the muddy shores of this great lagoon, or Zee, as the Hollanders prefer to call it, are some famous old towns once of greater account to the world than our own Chathams, Deptfords or Plymouths. They are the towns which made the Netherlands, and also sent their ships on over the distant sea to make East Indian, Australian and Cape history. Perhaps the most ancient and celebrated of these old naval stations is Hoorn, where the formidable fleet of Admiral De Ruyter was built, where Abel Janssen Tasman first saw the light, and whence Schouten, an almost forgotten navigator, sailed in the year 1616, when he discovered and gave the name of his native city to the world-renowned promontory of South America. Recently it has been said that Tasman sailed from the Zuider Zee in 1642 for the discovery of Australia, or rather for discovering its extent, but that is not strictly correct, because it was from Batavia, in Java, where the expedition was fitted out, and from which port his two historic ships, the Heemskirk and Zeehaan, departed, on the 14th of August of the above year, by commission of Anthony Van Dieman, the most distinguished governor-general who ever presided over the affairs of the Dutch in the East.

But the importance of old Hoorn has long vanished, and ancient or modern navies know it no more, for in, and for miles around, its extensive bay there are not more than nine feet of water at low tide.

When the tough old packet ships of the Dutch East India Company sailed from their native Holland, Hoorn or Amsterdam were the places where they were fitted out, and whence they were warped or sailed by devious and tedious courses northward through the well-buoyed channels of the Zuider Zee, to fill up with cargo, water and provisions at or near the Texel, where existed the advantages of deeper water; but as the ships grew in tonnage and draught, it was at length discovered that other measures would have to be undertaken in order to preserve the valuable and growing trade of Amsterdam. It was not, however, till some years later that Holland set herself the task of constructing a harbor at Nieuwe-Diep, and afterward the famous Helder Canal. For this purpose the Helder Dike had first to be formed, in order to protect the works from the fury of northwest gales. This great monument of Dutch industry, perseverance and skill, was six miles in length and forty feet broad on the summit. It presented to the sea an inclined face of 300 feet at an angle of 40°, the whole being constructed of massive granite blocks brought by ships from Norway.

The Helder Ship Canal was completed in 1825, and, like that of Suez, is one of the greatest works of this century. It was cut from the sea at Helder, a distance of fifty miles southward to Amsterdam, and passed the seacoast near Kamp at not more than one and a quarter miles distant. It was the success of this work, cut through a sandy soil chiefly, which convinced M. Lesseps that his scheme at Suez was possible, although the former was on a much smaller scale, for its greatest depth was but 18½ ft., its width at the bottom 31, and at the top 123¼ ft. But the tonnage and draught of merchant ships went on increasing so fast that, in 1865, a company was formed for reaching the North Sea by a still nearer route of 16½ miles, striking direct from Amsterdam westward through Lake Y (pronounced I) and the Wyker Meer. The existence of these lakes only necessitated a cutting of three miles through dry land, together with the construction of two piers built of massive concrete blocks, their flooring being the sandy coast which first receives the gigantic northwest waves all the way from the Texel to the Scheldt. Through this canal now passes the chief sea trade of Amsterdam, which, with a depth of 23 ft., was finished in the year 1876–77, at a cost £2,250,000.

As to the drainage of the Zee, roughly speaking, there will be something like 1,300 square miles of water, with an average depth of 12 ft., to be drained off after the construction of a dam at Wieringen, which cannot be much short of fifteen miles in length. Hydraulic engineering is well understood in Holland; it is one of the chief functions of the Waterstaat, a public department entirely devoted to such work; that is the reclamation of land by the drainage of lakes, the embanking of rivers, and the care of the dikes, which alone keep the ocean from swallowing up the greater part of their country, lying as it does so far below sea level. But the waves of the North Sea, though treacherous and formidable enough, are not Holland's worst enemy, for when the numerous rivers are swollen by heavy and continuous rains, the natural rise of alluvial deposit compels the rising of the embankments on each side for hundreds of miles all over the country, compared to which the dikes on the sea coast are of little account.

These sea dikes are often thrown up by the force of the sea alone, but where that force fails, recourse is had to the construction of ramparts, formed by piles at the base for the purpose of supporting an enormous superstructure of stones and earth.—*Nautical Magazine.*

RECENT PHOTOGRAPHIC LENSES.

About the beginning of this year a new photographic lens, invented by Messrs. Goerz and Von Hoegh, of Berlin, came into the market; it is popularly known as the Goerz lens, and has made its mark. The most generally useful lenses employed for many years past, when the photographer confines himself to but one, have been those of the doublet type, in which two achromatic meniscus combinations are mounted in one tube, with their concave surfaces facing each other; the diaphragm is midway between the two. This type of lens does well for architecture—for it gives straight marginal lines—and for landscapes. The new Goerz lens is of the doublet type, but its front and back combinations each consist of three cemented elements instead of two, and so designed as to give a more perfect image than the older doublets, especially in the matter of getting rid of astigmatism; indeed, it seems to have pushed perfection in doublet lenses about as far as it is possible to go. The lens itself is represented in Fig. 1.

In the words of the inventors, it consists of a photographic doublet, the two component systems of which are each corrected for spherical, chromatic, and astigmatic errors, being to this end made up of three lenses—(*a*) of a negative lens inclosed between two positive lenses, one of which has a higher and the other a lower refractive index than the inclosed negative lens; or (*b*) of a positive lens inclosed between two negative lenses, of which one has a higher and the other a lower refractive index than that of the inclosed positive lens. In this country the lens is manufactured by Messrs. Ross & Co.

Another lens, invented some months before that of Goerz, possesses some remarkable optical features, and is useful for special rather than general purposes. It gives a more perfectly flat field than any other lens in the market; so is useful for copying purposes, and for photographing nearly flat surfaces in front of the lens, and filling nearly the whole of the field of view. It is not rapid, for the largest aperture of diaphragm with which it can be conveniently used is in diameter $\frac{1}{11}$ of its focal length. It is known as the "concentric lens," is made by Messrs. Ross & Co., and is represented in Fig. 2.

The chief optical peculiarity of this lens is that it

Fig. 1

Fig. 2

consists of two concave combinations, which were they made of one piece of glass would not give a positive image, but by the selection of a suitable crown glass for the positive element, of higher refraction than the flint of the negative element, the rays are caused to converge. By the special effect of refraction on the oblique pencils, the lens, although of this peculiar form, gives a real image, free from distortion, on an absolutely flat field, and extending over a circle of about 75°. The whole is practically as equally illuminated as theoretical limits will permit.—*The Engineer.*

THE SCHOENZELER PHOSPHOR-COPPER PROCESS.

PHOSPHOR-COPPER CONTAINING A VERY HIGH PERCENTAGE OF PHOSPHORUS (UP TO 20 PER CENT.) AND PHOSPHOR-BRONZE (ALSO FOR TELEGRAPH AND TELEPHONE WIRE).

Phosphor-copper.—The more free from pores and the more homogeneous an alloy, by so much is the casting produced stronger, tougher, and more elastic.

Bronze and other alloys, the basis of which is copper, when in a liquid state, contain oxygen, and in the proportion of the volume of oxygen the casting is porous.

But if phosphorus is introduced into the liquid mass, it (the phosphorus) unites with the oxygen and by combustion destroys it, thus preventing the production of porous castings.

The tin contained in alloys is not easily crystallized, but by the introduction of phosphorus into the mass the tin becomes crystallized. Two crystallized metals form a more homogeneous alloy than metals, one of which is crystallized but the other not, and therefore, bronze containing phosphorus is far more homogeneous than common bronze without phosphorus.

Phosphorus furthermore possesses the desirable property of rendering an alloy highly fusible. Thus the molten mass will fill the very minutest parts of the mould and produce most exact castings.

For those reasons the following advantages will result from the introduction of phosphorus into alloys:

First. Phosphorus, by destroying the oxygen contained in the liquid mass, prevents porous castings.

Second. Phosphorus causes tin to crystallize; thereby the alloy is rendered homogeneous, and gains in strength, toughness and elasticity.

Third. Phosphorus imparts to the alloy a high degree of fusibility; wherefrom results exact castings.

Fourth. Phosphorus reduces the loss in casting; thereby it lessens the expense in making bronze.

However, the introduction of phosphorus into a molten mass of metal has heretofore not been accomplished without considerable and apparently unavoidable loss of that chemically very active substance. Moreover, it has not been found possible to introduce into the alloy any greater quantity of phosphor-copper than 10 per cent. of the metals' weight.

Either defect is remedied when a phosphor-copper is used, the process of manufacture of which has been discovered recently by John Schoenzeler, of Cologne on the Rhine, Prussia. This new composition contains as much as 20 per cent. of phosphorus instead of the 10 per cent. to which the introduction of phosphorus into copper or its alloys has been limited heretofore. It not only imparts to any alloys being formed by new material all the desirable qualities enumerated above, but it also is most advantageously used for the renovation of old bronze, brass and scrap gun metal, to which it renders the original quality and purity.

Alloys harden by an addition of tin, lose in toughness, and are rendered brittle in proportion to the percentage of tin used; the new phosphor-copper, on the contrary, not only imparts to the alloy any desired degree of hardness, but produces that effect, while at the same time enhancing the strength, toughness and elasticity of the casting.

Finally, alloys containing phosphor-copper have the advantage of not being liable to oxidation.

Considerable saving of time and great convenience resulting from the use of Schoenzeler's phosphor-copper are further points worthy of consideration. Cast in plates that may readily be broken up into small pieces of equal weight, the phosphor-copper is added to the liquid mass, at once thoroughly mixing with it and without developing those stifling vapors so obnoxious to foundrymen.

Phosphor-bronze.—The degree of hardness imparted to phosphor-bronze is dependent on the quantity of phosphor-copper added to the alloy. It naturally varies with the purpose the casting is intended for.

Schoenzeler produces ten different marks of phosphor-bronze:

I. Axle bearings, for looms, lathes, etc.

II. Screws, bolts, etc.

III. Axle bearings for locomotives, railroad cars, carriages and parts of machinery exposed to great friction and violent shocks.

IV. Tubes of condensing apparatus, and parts of furnaces.

V. Sliding valves.

VI. Hydraulic pumps, faucets required to withstand the action of acids, bearings for axles revolving rapidly (dynamo machines, torpedo boats, etc.)

VII. Cog wheels, torpedoes, screw propellers, etc.

VIII. Various tools, crushing machines, machinery for powder mills.

IX. Steam cylinders, reservoirs required to withstand an uncommonly high pressure.

X. Purposes demanding extraordinary hardness and toughness of the casting.

In his calculation of the proportion of component parts of the alloy most suitable for axle bearings John Schoenzeler was guided by the following points:

First. The alloy must not exert any detrimental influence on the journal.

Second. The bearing itself must in the least possible way suffer from tear and wear.

Third. The bearing must not readily run hot.

Fourth. The quality of lubricating material required must be limited to a minimum.

Fifth. The bearing must resist any possible pressure or shock, without change of form.

Having succeeded in composing an alloy for axle and journal bearings answering the enumerated points, John Schoenzeler has received many certificates from leading railroad and steamship companies, all stating that the cost of his axle bearings in proportion to the cost of bearings made of different metals proves to be:

8 axle bearings to white metal bearings	1:3·1—3·8
8 axle bearings to red casting bearings	1:2·2—2·6
8 axle bearings to lead composition	1:1·8

Durability of phosphor-bronze = 4:1 in comparison with manganese-bronze.

However, the purposes enumerated above are by no means the only ones to which phosphor-bronze may be applied.

Schoenzeler's European works of late are receiving large orders for phosphor-bronze plates to be drawn into telegraph and telephone wires. Wires made of this material offer but little resistance to the passage of the electrical current, and are not liable to oxidation, and much lighter and more durable than any wire heretofore used. The German government does not allow these wires to offer any higher resistance than 5·5 to 6·14 ohms per kilometer. A 2 mm. wire must stand being bent in a right angle nine times before breaking.

THE ANALYSIS OF VARNISHES.

In the course of a paper contributed to the *Journal* of the American Chemical Society, Mr. P. C. McIlhiney gives the following method for the estimation of turpentine in varnishes. He contends that the requirements of a satisfactory process for determining turpentine are:

(1) That the volatile material shall be separated under conditions which admit of its being actually weighed or measured, and then submitted to further treatment. (2) That the non-volatile portion shall be subjected to as little heat as possible, both to avoid any destructive distillation and to leave it unaltered for further examination. (3) The process should require no unusual apparatus. None of the processes which he previously describes fulfill the above conditions. It is well known that on distilling together two immiscible liquids, such as carbon disulphide and water, the boiling point of the mixture is lower than that of the more volatile liquid. Carbon disulphide boils at 49°, but when distilled with water the boiling point of the mixture is 43°.

On distilling together 100 c. c. of water and five c. c. of turpentine, it was found that the first ninety-five c. c. of distillate contained all the turpentine, which separated very well from the water. Experiment showed that ninety c. c. of water either dissolve or hold in suspension

permanently about 0·3000 gramme of turpentine. On these principles the following process was devised:

Estimation of Turpentine.—Twenty-five grammes of varnish are weighed into a flask of 400 c. c. capacity, in which has been placed a piece of granulated tin, or its equivalent, to prevent bumping, and about ten c. c. of water. The flask is in this way prevented from becoming greasy, which would cause violent bumping. The contents of the flask are now submitted to distillation, the distillate being caught in a tapped separator. When ninety or ninety-five c. c. of water have come over, the distillation is stopped and the turpentine and water allowed to separate. If the contents of the flask still retain any odor of turpentine, more water should be added and the distillation resumed. After settling for a sufficient length of time, the water is carefully drawn off and the turpentine poured into a tared flask and weighed. A correction is made for the amount of turpentine retained by the water, amounting to 0·300 gramme for ninety c. c. of water. In some experiments salt was added to the water to raise its boiling point, but no apparent advantage was gained, except when the non-volatile residue was heavier than water; in this case the salt prevented the residue from sinking to the bottom and causing bumping by greasing the flask. If it is desired to examine the residue, the remaining water is poured off from it and alcohol added. On distilling off the alcohol, and if necessary removing the last of it by the addition of a little ether, which is also evaporated off, the residue is obtained pure.

The following results were obtained by this process:

Varnish.	Per cent. found.	Per cent. present.
B	41·2	41·4
C	57·1	56·9
D	56·3	56·8

The sample D was made by dissolving common resin in turpentine, and it was therefore more difficult to remove the last trace of turpentine from the non-volatile residue than it ever is in an oil varnish, but even in this case the result is fairly accurate.

The method requires no unusual apparatus, and can be carried out in about half an hour. The residue is not heated above the boiling point of water, and the turpentine is actually weighed and may be itself analyzed.

For the determination of benzine in turpentine, the method of Burton gives the best results. It depends upon the conversion of turpentine into acids soluble in water by the action of nitric acid, while benzine remains unaffected and is separated and measured or weighed.

The Non-Volatile Portion.—The analysis of the residue, consisting of linseed oil and resin, both more or less altered by heat, presents an extremely difficult problem in proximate analysis, and one which yet remains unsolved.

LIQUID AIR.

By J. J. STEWART, B.A. Cantab., B.Sc. Lond.

IT is a familiar fact to all that some substances can be obtained in the varying forms of solid, liquid, and gas; but many substances come under our notice only when occupying one of these states. When granite is mentioned we at once think of a hard, solid rock; few people have seen granite in a liquid state. Again, the name *mercury* calls to our mind the well known liquid metal. So there are numerous gases and vapors which are known to us only under this somewhat impalpable and less tangible form. Among the substances familiarly known to us, however, there are a large number which, through the action of heat upon them, can be readily changed into a fluid and then into a vaporous state. Perhaps the best known of all is water, though even this in hot climates is rarely seen in the there uncommon solid form; so that the African chief, who had accepted many statements from his European visitor, utterly refused to believe him when he was told that, owing to the intense cold in some countries, rivers got hard enough to be walked over.

Lately, in many text books of science, gases were divided into two classes—those which could be liquefied by the application of cold, or pressure, or both, and those which were *permanent*, or were known to us only in the form of gases. It was suspected by scientific men, especially after the extensive experiments by Faraday, who succeeded in liquefying many of the "permanent" gases, that all gases without exception could be changed into the liquid form if they were exposed to a sufficiently great pressure and at the same time cooled down far enough. This surmise has been proved correct only within comparatively late years, and now all gases, including the air we breathe, must be considered as differing from vapors, such as steam, only because at the usual temperatures at which we generally deal with them they are in a condition similar to that which other substances attain when heated to a very high temperature.

I propose to give a short account of the work hitherto done in the liquefaction of gases, commencing with that so ably carried out by that unsurpassed experimenter, Michael Faraday, and going on to refer to the researches commenced by Raoul Pictet and by Cailletet, in France, who, about the same time (1877), succeeded in liquefying oxygen and even hydrogen. These researches were pursued by Wroblewski and Olzewski, in Russia, and have been continued lately in our own country by Professor Dewar, who, with such striking success, has liquefied air in large quantities, and has even handed it about in pint bottles for inspection by a large audience.

There are two means open to us of liquefying a vapor. Let us increase the pressure upon it, or lower its temperature, and if we proceed far enough in these operations the vapor will become liquid. A further condition is necessary with the "permanent" gases—we must cool them down below their *critical temperature*. This critical temperature is that above which no amount of pressure applied to the gas will be capable of changing its state into that of a liquid.

Faraday, in his series of experiments, applied the simple but effective means of generating the gas in a strong glass tube, from those compounds which evolved the required gas on heating. In this way the gas, being produced in a limited space, produced a great pressure, under which pressure of its own vapor the gas became a liquid. On breaking the tube the gas, compelled by pressure to exist as a liquid, would revert to the form natural to it at the temperature of the experiment, and would do this with explosive violence. There was thus always a tendency for the gas to burst the tube, and this sometimes occurred during Faraday's experiments. Hence he was careful to wear a mask made from wire gauze or thick glass, but even thus he did not entirely escape injury. Faraday immersed one end of his tube in a freezing mixture while the other was exposed to heat. In this way he succeeded in liquefying a large number of gases, and examined their properties while in this unusual state. Among the gases so treated were the following: Carbonic acid, hydrochloric acid, sulphur dioxide, cyanogen, ammonia, and chlorine. He carried out his first set of experiments on this subject in the year 1823. Later, in the year 1845, after Thilorier had shown how carbonic acid gas could be obtained in the liquid form on a large scale, and also as a solid, Faraday used the solid carbonic acid mixed with ether, and by means of the cold produced by the evaporation of the mixture he reduced the temperature to about —100° Cent., and obtained most of the above mentioned gases, and also nitrous oxide, not only in a liquid but also in a solid state. Hydrochloric acid, hydrogen arsenide, ethylene, silicon fluoride, boron fluoride and chlorine he at this time managed to get in the liquid form, but was unable to solidify these substances. The gases hydrogen, oxygen, nitrogen, nitric acid, carbon monoxide, and marsh gas resisted all Faraday's attempts to liquefy them, and it was not until more than thirty years later that these substances were condensed.

Andrews, by his classical researches on the critical point of gases and vapors, and especially by his thorough investigation of the behavior of carbon dioxide when exposed to great pressure at varying temperatures, paved the way for future work on the liquefaction of gases, and showed that great pressure of itself was not sufficient to cause a gas to turn into a liquid, but that a certain limiting temperature must be passed in cooling down the gas before it can by any amount of pressure be liquefied. Thus above this limiting or critical temperature, which is different for each gas, it may be called truly permanent, while below this temperature the gas is liquefiable if only enough pressure is applied to it, and the gas may then be described as a vapor.

When substances evaporate or change from the liquid to the gaseous state, a large amount of heat disappears or becomes latent, and is used up in separating the molecules of the liquid farther apart and giving them increased energy of motion. On account of this disappearance of heat during evaporation great degrees of cold may be produced, and it was by this means that Pictet, in 1877, obtained a temperature of —140° Cent., and obtained oxygen in the liquid state. He cooled liquid carbon dioxide by surrounding it with liquid sulphurous acid, kept boiling in a vacuum, and got a still greater degree of cold by then allowing the liquid carbonic acid to evaporate rapidly in an exhausted space. The oxygen was generated in the usual way from potassium chlorate, a salt which splits up and gives off oxygen gas when it is heated; but the gas was produced in a strong iron retort, so that by means of its own pressure alone the gas was compressed by a force several hundred times greater than that of the ordinary pressure of the atmosphere.

The method adopted by M. Pictet is the same in principle as that employed by Faraday. The gas is generated in a closed vessel capable of standing a great pressure, and it is condensed by being simultaneously exposed to great cold and to the pressure of the gas itself, forced to occupy a very small space. In Pictet's original experiment he obtained a temperature of —130° Cent., at which temperature oxygen is liquefied, when the pressure is raised to 273 atmospheres.

While Pictet was continuing his experiments and endeavoring to liquefy the hitherto permanent gases, the same subject was being investigated by Cailletet, and it was on the same day, the 24th December, 1877, that the French Academy was informed of the success of both these experimenters in liquefying oxygen. Cailletet attained his object by exposing the gas to enormous pressure, produced by means of a hydraulic press, while at the same time the temperature was lowered by suddenly allowing the gas to expand. In this way a sudden disappearance of heat takes place, the heat energy becoming transformed into mechanical motion of the particles of the expanding gas. In Cailletet's apparatus the pressure was produced by a steel piston working in a cylinder, the hydraulic cylinder being filled with water. The gas was contained in a capillary glass tube with small bore and thick walls which could support the strong pressure required. The glass tube containing the gas was connected to the hydraulic pump by means of a flexible metallic tube. Cailletet worked with small quantities of gas, while Pictet, by means of his machinery, was able to obtain relatively large quantities of the various liquefied gases.

The results got were only obtained after years of preparation and endeavor by both experimenters, working quite separately and independently. Cailletet made use of the skill and knowledge obtained by him in the prosecution of his business as an ironmaster at his works at Chatillon-sur-Seine; while Raoul Pictet carried on his experiments at Geneva, where he was engaged as a manufacturer of ice-making machinery.

Cailletet's apparatus is singularly simple and effective, and by it he also obtained liquid hydrogen, which appeared as a mist on the inside of his tube when the great pressure to which the gas was subjected was suddenly relieved, and heat thus suddenly absorbed. Hydrogen was thus liquefied into globules of mist on the glass when the pressure of three hundred atmospheres was suddenly removed, while air previously carefully dried changed into a liquid under a pressure two hundred times that of the atmosphere after it was cooled by means of liquid nitrous oxide. This is what happens in Cailletet's experiment: the gas, first of all cooled on account of its quick expansion, descends in temperature below its critical point, and then becomes liquid under the moderate pressure to which it is then exposed. But as expansion and relief of pressure continues, the liquid is soon under too little pressure to remain in this condition, and besides by conduction from surrounding objects heating occurs, so that the liquefied gas soon evaporates and the mist produced is fugitive; this is especially so in the case of hydrogen.

MM. Wroblewski and Olzewski have carried out many experiments, using an apparatus similar to Cailletet's. At —136° Cent. a pressure of twenty atmospheres sufficed to liquefy oxygen, and the critical temperature of this gas is placed at —112° Cent., that is, it must be cooled *at least* as far as this before liquefaction can take place. The critical temperature of nitrogen is found to be still lower than this, being —147° Cent., or —223° Fah.

On Friday evening, June 26, 1891, at the Royal Institution, the audience saw liquid oxygen in large quantities freely drawn off from the refrigerating apparatus, and having all the appearance of hot water, with a vaporous cloud above it. In reality the oxygen was boiling at a temperature of —296° Fah., *i. e.*, 328° below freezing point, and the apparent vapor consisted of ice particles produced from the moisture of the surrounding air, cooled from the contact of the chilled gas. On filtering the liquid oxygen, to get rid of the minute particles of solid carbonic acid scattered through it, it was seen to consist of a blue limpid liquid not unlike water. It would naturally be expected that the liquefied gas when placed in an open vessel in a room at the ordinary pressure and temperature would with great rapidity, and even violence, hasten to take the gaseous form. But this was not the case; the liquid oxygen evaporated but slowly, and retained its liquid form for a considerable time, although it was only under the usual atmospheric pressure. When a few drops of the liquid were thrown into water, the effect was like that of plunging red hot iron into a liquid; a fizzling noise was produced, and soon the globules of liquid oxygen were seen each floating about in a little cup of ice formed from the surrounding water. By means of the remarkably cold fluid, alcohol, which remains liquid in even in the severest Arctic climate, was quickly frozen into solid lumps; the solidifying temperature for alcohol being —130° Cent.

The effect of cold in rendering sluggish and inert substances which are usually chemically active is strikingly seen in the case of cooled oxygen. At ordinary temperatures oxygen gas has a great affinity for phosphorus, and combines readily with it, producing vigorous combustion with much heat, and light clouds of the solid phosphorous oxide being formed. But a piece of phosphorus when placed in liquid oxygen remains undisturbed; no combination takes place.

By means of liquid oxygen, nitrogen may be liquefied. Advantage is taken of the fact that liquid oxygen when placed in vacuo boils at a lower temperature than when under the ordinary pressure. A temperature of —328° Fah. can thus be obtained, at which both nitrogen and atmospheric air can be liquefied. During the process of liquefaction of air the two gases of which it is made up become liquid together, but when the temperature is allowed to rise they evaporate separately. The nitrogen, though more difficult to liquefy, comes off as a gas first, leaving almost pure oxygen behind.

Prof. Dewar has also solidified air as well as nitrogen by employing powerful pneumatic apparatus. Pure oxygen has itself never been obtained in the solid form. In order to obtain a succession of lower and lower temperatures, the various liquefied gases are caused to boil in a vacuum. Thus the more easily liquefiable gases are made use of to abstract heat on their evaporation from those more difficult to liquefy. When these latter are made to boil in vacuo a still lower temperature is attained, and by successive steps a reading on the thermometer as low as —211° Cent. (or —346° Fah.) has been reached. At these low temperatures experiments of an interesting character have been made on the electrical behavior of metals, and their electrical resistance has been determined.

On boiling successively in vacuo carbonic acid, nitrous oxide and ethylene, using the first to take away by their evaporation heat from the gases which are more difficult to liquefy, a temperature of —229° Fah. is reached, at which oxygen can be liquefied under a pressure of fifteen hundred pounds per square inch. The rapid evaporation of oxygen in vacuo so quickly removes heat from surrounding substances that air and nitrogen are soon liquefied, and these, when treated under powerful air pumps, abstract sufficient heat to allow the production of solid nitrogen. This last experiment was successfully carried out for the first time in public on January 19, 1894.—*Knowledge.*

LEAD WATER PIPES.

THE tests described in this paper were made upon the new water supply of the city of Belgrade (a full analysis of the water is given). This water contains iron, calcium and magnesium salts, is of 24·8° total hardness (German scale), and holds in solution more than 0·5 grm. CO_2 per liter.

Lead was tested for, in water which had stood overnight in the pipes, as follows: One liter of water acidified with acetic acid was evaporated down to 100—200 c. c., filtered, and a drop of dilute sulphureted hydrogen water added. If lead is present, even in the most minute quantity, a darkened coloration of the water is observed. As this reaction might be partially obscured by the precipitation of the iron present in the water, it is necessary to make a test at the same time with a sample known to be free from lead.

An estimation of the amount of lead may be carried out with great accuracy in the following way: One liter of the water is acidified with 5 c. c. glacial acetic acid, concentrated to 100 c. c., filtered, and one or two drops of dilute H_2S water added (one part saturated H_2S water with two parts distilled water). At the same time the sample known to be free from lead is treated in an exactly similar manner. If lead is detected in the first sample, add to the second such an amount of a solution containing 0·1 mg. lead in 1 c. c. that the two solutions have exactly the same color. The amount of lead added to the second sample is the amount present in the first. By this means 0·05 mg. lead per liter may be estimated.

In carrying out the tests here described, a piece of lead pipe 7 meters in length and 22 mm. in diameter was employed. The solvent effect of the water on the lead was greater at first than after the tube had been some time in use. But even after three months, about 0·3 mg. lead per liter was found in water which had

stood 24 hours in the pipe. After three hours' standing a trace of lead was detected, but in water which had merely run through the pipe no lead could be found. Therefore, where lead pipes are used the water should be allowed to run for a few minutes before taking it for drinking purposes.

The somewhat large amounts of lead dissolved by this particular water may be due to its richness in free carbonic acid. The author recommends that subsequent papers on this subject should include a full analysis of the water, in addition to the method adopted for estimating lead. If this suggestion were fully carried out, it would be possible, with the help of medical men who would inform us as to the amount of lead rendering water unfit for drinking, to definitely solve the question of the suitability of lead pipes for conveying water.—*M. T. Lecco, Chem. Zeit.*, 17, 1431–1432.

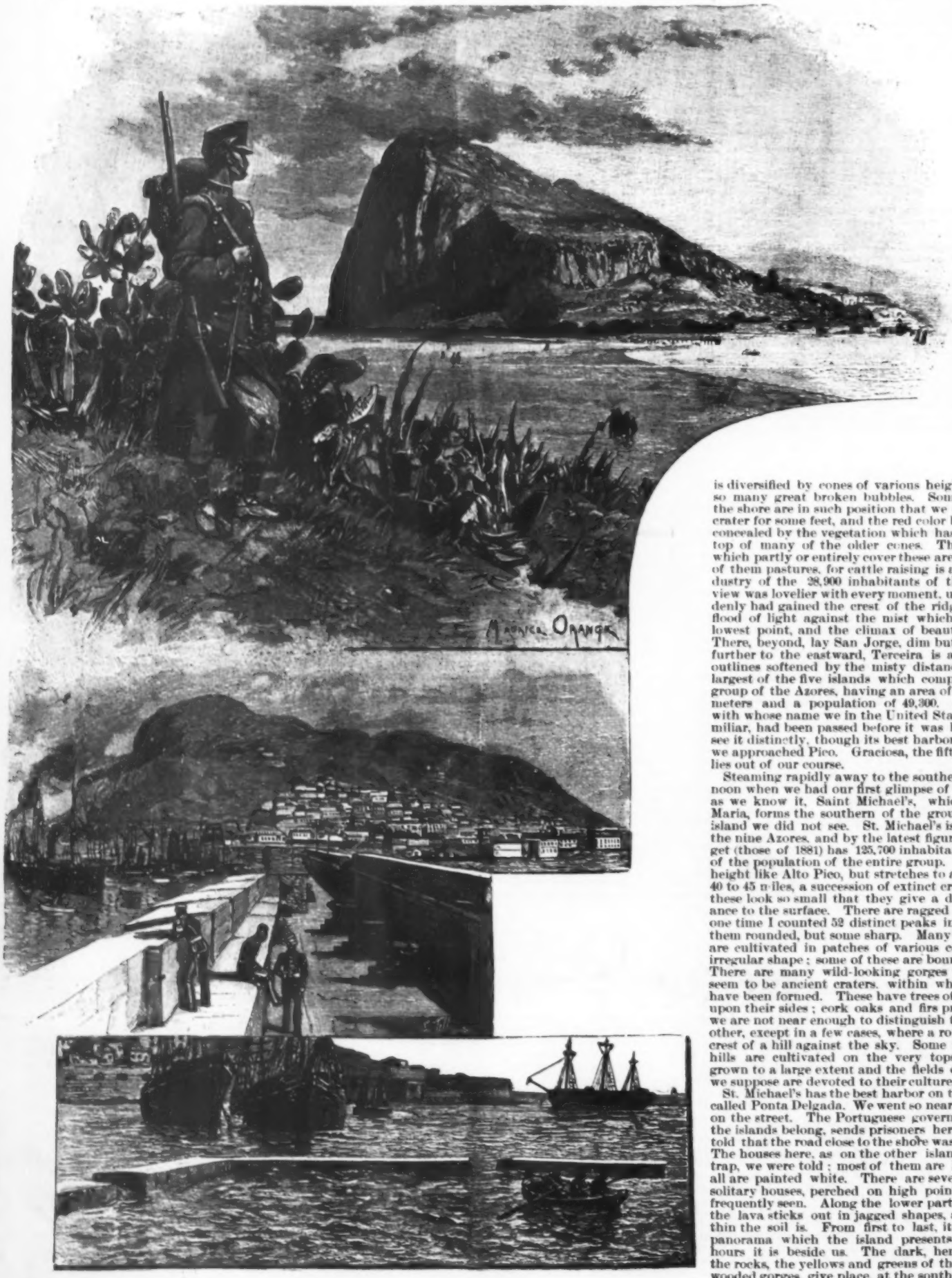
A SUMMER VOYAGE TO ITALY, THE AZORES, GIBRALTAR, GENOA.

When the North Atlantic had become a race track for the great English steamers, the North German Lloyd Company began their Mediterranean service between New York and Genoa. Their cabin lists are full even in summer, and the voyage offers so much of charm, variety and comfort that one does not begrudge the eleven days which it consumes.

The first five days on the Fulda, which sailed from New York on June 16th, were devoid of any special interest, but on the afternoon of the 6th we sighted Flores, the western of the Azores. Its rocky sides, sharply outlined against the sky, whetted our desire for the nearer view we were soon to have of the islands of the second of the three groups in which the Azores are set. And the next morning, the same strain of the bugle which called us three times a day to meals summoned us at half-past three to the deck. There in the gray mist stood Alto Pico, close beside us. It is the highest volcano of this volcanic group, and rises 7,613 feet from the sea, while below it the ocean is said to be 21,000 feet deep, making it one of the striking examples of submarine volcanic action. But our first impression was of the beauty of the scene. The mountain rises sheer from the water's edge, brown and rugged; a heavy cloud lay along its side, hiding perhaps half of it, but clear and distinct above the main mass stood the topmost cone, set there as if by some Titan's hands. We steam slowly along, and as the cloud gradually moves off, we see low white houses clustered into villages in the wider valleys, and above them the dark, deep crevasses which have been torn by the long-spent force within. From the highest peak the island gradually decreases in level, but the whole surface is diversified by cones of various heights, looking like so many great broken bubbles. Some of those near the shore are in such position that we can see into the crater for some feet, and the red color has not yet been concealed by the vegetation which has climbed to the top of many of the older cones. The patchy fields which partly or entirely cover these are probably many of them pastures, for cattle raising is an important industry of the 28,900 inhabitants of the island. The view was lovelier with every moment, until the sun suddenly had gained the crest of the ridge, and threw a flood of light against the mist which hung over the lowest point, and the climax of beauty was reached. There, beyond, lay San Jorge, dim but massive; soon, further to the eastward, Terceira is also in sight, its outlines softened by the misty distance. This is the largest of the five islands which compose the middle group of the Azores, having an area of 578 square kilometers and a population of 49,300. Fayal, the one with whose name we in the United States are most familiar, had been passed before it was light enough to see it distinctly, though its best harbor was in sight as we approached Pico. Graciosa, the fifth of the cluster, lies out of our course.

Steaming rapidly away to the southeastward, it was noon when we had our first glimpse of San Miguel, or, as we know it, Saint Michael's, which, with Santa Maria, forms the southern of the groups. The latter island we did not see. St. Michael's is the largest of the nine Azores, and by the latest figures I am able to get (those of 1881) has 125,700 inhabitants, nearly half of the population of the entire group. It has no great height like Alto Pico, but stretches to a length of from 40 to 45 miles, a succession of extinct craters. Many of these look so small that they give a dimpled appearance to the surface. There are ragged heights, too; at one time I counted 52 distinct peaks in sight, most of them rounded, but some sharp. Many of the hill sides are cultivated in patches of various colors and most irregular shape; some of these are bounded by hedges. There are many wild-looking gorges inside of what seem to be ancient craters, within which newer ones have been formed. These have trees of gloomy aspect upon their sides; cork oaks and firs predominate, but we are not near enough to distinguish them from each other, except in a few cases, where a row stands on the crest of a hill against the sky. Some of the rounded hills are cultivated on the very tops; potatoes are grown to a large extent and the fields of darkest color we suppose are devoted to their culture.

St. Michael's has the best harbor on the Azores; it is called Ponta Delgada. We went so near as to see people on the street. The Portuguese government, to which the islands belong, sends prisoners here, and we were told that the road close to the shore was made by them. The houses here, as on the other islands, are built of trap, we were told; most of them are low and nearly all are painted white. There are several towns; and solitary houses, perched on high points, are not unfrequently seen. Along the lower parts of the shore, the lava sticks out in jagged shapes, and shows how thin the soil is. From first to last, it is a beautiful panorama which the island presents for the three hours it is beside us. The dark, hemitic brown of the rocks, the yellows and greens of the fields and the wooded gorges, give place, at the southern end, to barren pumice-colored heights, and we are less regretful to lose sight of the picture. Life upon the Azores, we are told, is very primitive; donkeys are the only means of conveyance used. The islands are certainly too far



THE ROCK OF GIBRALTAR.

1. The rock as seen from the Spanish lines. 2. The city as seen from the jetty. 3. Submerged dikes in front of the recent batteries.

apart to have much communication with each other, and the steamers from Portugal are not frequent.

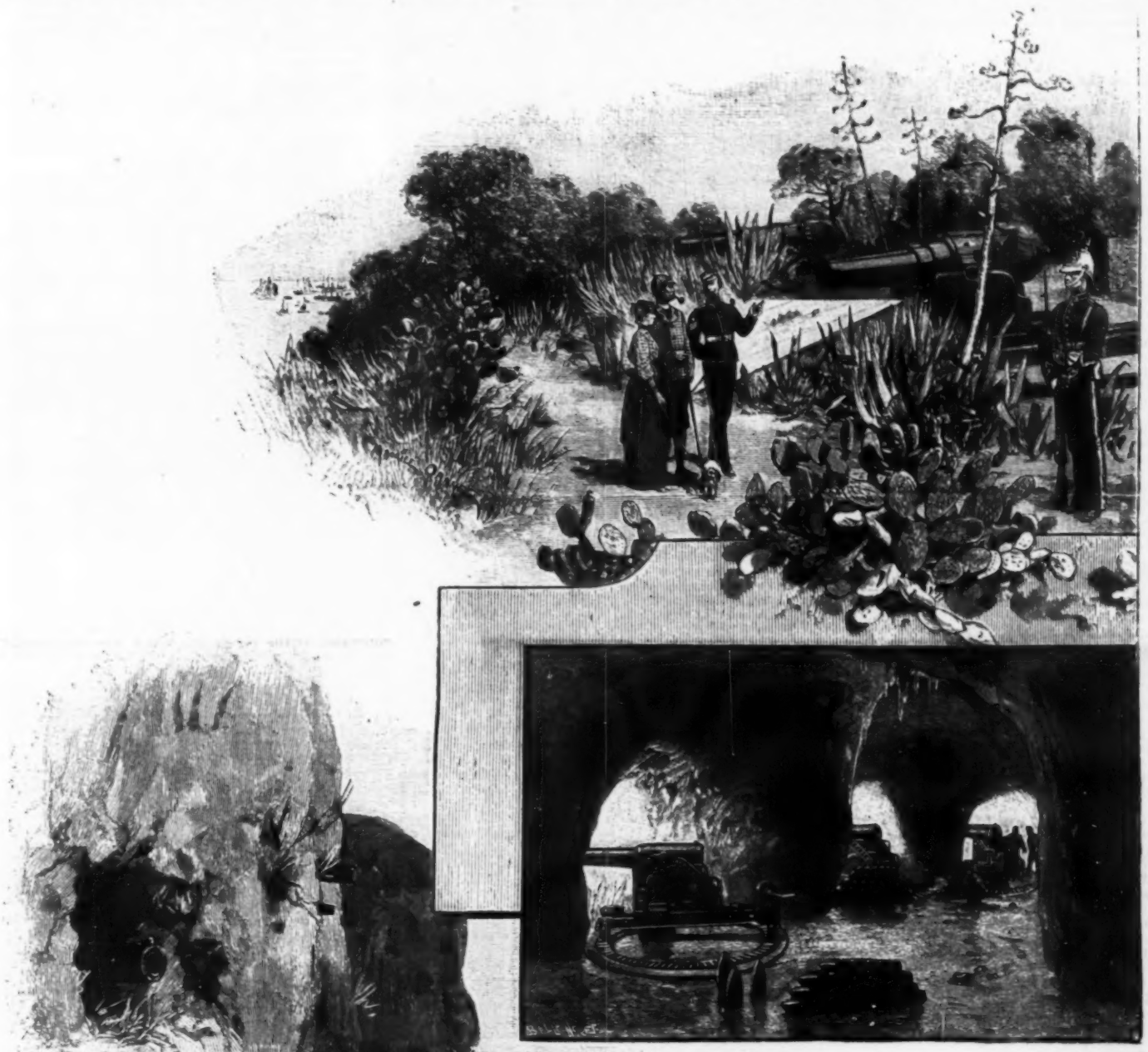
Again we had only the waste of waters about us for two days, but the first light of Monday, the 25th, showed us the African coast, with the bare, sharp foot hills of the Atlas Mountains in full view. By six o'clock we are close to

GIBRALTAR,

and at seven we drop anchor in the bay near the new mole. What looked to our unaccustomed eyes like a squadron of English men-of-war, and other vessels, lay in the harbor. On the man-of-war nearest us, with its guns in full view, the marines in white suits were on the deck, and added much to the animation of the scene. Small boats from the shore had watched for our approach, and men with baskets of fine strawberries and other fruit, and with packages of embroideries, etc., climbed aboard almost before we had come to rest, tempting passengers to buy from them rather than go ashore.

The view of the peninsula from the bay is most picturesque: the Spanish mountains are low and barren and brown; then comes a flat valley and from it rises the famous rock, gray, massive and portentous. It is well called "Le lion couchant," for it closely resembles a lion, lying with gigantic head toward the Spanish territory, and its body stretching toward Europa Point, the extremity of the peninsula, three miles away. The yellow houses along its lower part compose the English town; this is defended by the "Line Wall," two miles in circuit, which is broken by bastions containing mighty guns ready to sweep an enemy from the bay.

We were taken ashore in a tender; and easily engaged a light carriage for a drive. An English official gave the permit which passed us into the narrow precipitous streets. Although so early in the morning, the cosmopolitan population seemed to be all out: there were Moors in red garments and white turbans, others dressed wholly in white, in loose flowing robes; there were Turks in baggy trousers, and women with swarthy complexions and lace mantillas on their heads. Now and then a squad of English soldiers met us, as we drove up to the Alameda Gardens, where is their parade ground. Here we left the carriage, and mounted some steps, which lead into the park. At the head of these steps stands a bronze bust of General Eliott, the hero of the great siege. It is a strong, brave face, and one feels anew a thrill of admiration for the man who, during those years of close-threatening starvation, stood firm by his declaration, "I make it a point of honor to partake both of plenty and scarcity in common with the lowest of my brave fellow soldiers." The gardens are most beautiful: the flowers are abundant in many varieties, hedges of tall heliotropes make the air sweet, and palms lend a tropical look to the scene. It is a



THE ROCK OF GIBRALTAR.

1. Promenade and battery of Alameda. 2. The subterranean batteries.

place where one would love to linger, but we could not. Getting into the carriage again, we drove down through other narrow streets lined with little shops, where English and oriental signs and wares are strangely mingled, along by the fortifications called "Curtains," where guns of heavy caliber are in full sight. The Moorish Castle, which is a picturesque feature of the upper heights, is the entrance to the rock galleries. These we had not time to visit, but, as we drove along at the base of the rock toward the neutral line, we saw the rows of portholes, to the very top of the 1,400 feet of the rock; remembering that each one of these holes has a cannon behind it, and that they are all pointed at Spain, it is not difficult to understand why England has not lost her position since first she gained the stronghold. As matter of fact, these guns are fired together, but once a year, and that on the Queen's birthday. On that occasion, the "Rock Gun" on the topmost peak gives the signal, the cannon in the galleries follow, the batteries by the sea reply, and the mighty volume of sound sweeps round the bay and across to the African shore. Within this naturally strongest fortress in the world, a garrison of between five and six thousand men is kept.

A solitary sentinel was pacing the well-worn path on the neutral line as we crossed it and drove along the flat, dusty road, to the Spanish settlement. Here we found a crowd of heavily laden donkeys with their drivers, just starting to their market, the English quarters. Some of the little animals were loaded with two flat, round baskets of charcoal; others with two piles of fodder, each of which was larger than his own body. On some of the donkeys a woman was seated between the double burdens.

Once more we drove under the shadow of the frowning rock to the landing, where the tender was waiting

to take us back to the ship. Two hours on the ground had made Gibraltar more real to us than any historian ever could.

We were soon under full steam, and within an hour had rounded Europa Point and passed between the Pillars of Hercules, into the Mediterranean. It was calm and smooth as any summer sea can be until toward evening, and then so stiff a breeze sprung up that we kept, for some hours, so near the Spanish coast as to feel the fascination of the dimly outlined mountains.

On Wednesday, the eleventh day from New York, we were close enough to the French shore to see Nice and Mentone and the picturesque heights above them. It was easy to realize the charms that the Riviera must have for invalids from the North. Ventimiglia divides the French portion of this delightful region from the Italian. We could follow the famous drive with the eye, for some distance, and faintly imagine the beauty of the near view of those towering heights, with their ruined fortresses, the orange and olive groves, the half-hidden villages and villas, all looking down upon the Mediterranean.

GENOA.

Toward evening the panorama became more majestic, because more distinct as we approached Genoa, or *Genova la Superba* as the Italians well call this beautiful city on the sea. The hills upon which it is built are crowned by a wall, and there are ten forts, which help to make it both strong and picturesque.

Our first interior view of the city was had in the evening. After being settled in a hotel, where the lofty arched and frescoed ceilings, stone floors, iron doors, grated windows, and massive walls made us feel as if we had suddenly been dropped into the middle ages, we went out into the Piazza dell'Annunziata, and then through a number of the winding streets. They were thronged with people, who were loitering about as if out merely for the sake of being in the air. Music came from the pretty garden cafes. At one point, so many soldiers were massed that we could not pass. The news of President Carnot's assassination was fresh, and the government was taking means for protection against any anarchistic movement. The principal squares and streets are lighted by electricity, and I think it serves to heighten the quaintness of the narrow ones, as it gives grandeur to the more spacious streets. The long, long staircases, reaching quite across the narrow, hill side streets, are among the first curious features which the stranger notices. They are most interesting when one happens to catch a glimpse of three or four picturesquely dressed women, who are moving up or down with big loads upon their heads, apparently as unconcerned as if they were walking on a level.

We came in our evening stroll to the square where stands the fine new bronze equestrian statue of Victor Emmanuel. The horse is full of fire, and the king, with hat in his upraised hand, gives one a feeling that his leadership continues. Flower beds surround the statue. Just above it, a beautiful little park has been laid out on part of the old ramparts. A tiny cascade falls over the high rocks near its edge; the light thrown upon it gave it a silvery appearance and made a most charming picture. From the height above this waterfall we afterward had, by daylight, a glorious view of the city, the present ramparts, the Mediterranean and the mountains which are the beautiful background.

North of this park, and virtually adjoining it, is another. The chief object of interest in the latter is the noble white marble statue of Mazzini, one of Genoa's sons whom she delights to honor. The pose of the figure and the expression of the face are alike dignified; allegorical figures of Thought and Action are at his feet.

What better way to judge of the spirit and sentiment of its citizens than by the statues which adorn a city? There are two others in Genoa of special significance. One is of Garibaldi. This is also an equestrian statue, but the horse is lifeless, and the man, in his simplest of dress, suggests the gentleness which wins, rather than the firmness which leads on to action. For her world-famous Columbus, Genoa has set up her most pretentious statue. It stands near the chief railway station, in the midst of the wide Piazza Acquaverde. The statue is of white marble; the pedestal has ships' prows upon it, but projecting much less than do those on the pedestal of the New York statue, they are not objectionable. America kneels at the feet of the discoverer, and figures representing Wisdom, Strength, Science, Geography and Religion surround him at a little distance.

The one fact which every American child is likely to be taught about Genoa is that it was the birthplace of Columbus; this alone lends interest to the place; but on the ground one learns that Columbus "is supposed to have been born at Cogoleto," fifteen miles west of Genoa, on the Riviera.

The architectural glory of Genoa is in her palaces; a number of them were built in the sixteenth century by Galeazzo Alessi a pupil of Michael Angelo. For the most part, they are plain exteriorly, but very spacious, high and with massive walls. These are of stone, the lower windows are all grated, and the upper ones are shaded with green blinds. The other buildings of the city have the same general characteristics, though their walls are generally of rough stones, covered with plaster to make a smooth surface, and then painted. The color is almost uniformly a light gray; the green blinds are universal. Roof gardens and plants at doorways and upper windows among the more modest, houses give the verdure which the streets lack. Notwithstanding the uniformity in shape of the buildings, they are on such varying levels, and the streets are so irregular, that the eye receives an impression of pleasing variety.

To return to the palaces: They are put to all sorts of uses; the Via Garibaldi and Via Cairoli, two of the main business streets, are a succession of them, built in the sixteenth century; their lower parts are occupied as shops and offices. The municipal building is a grand palace, with imposing entrance and wide courtyard; the elegant Rosso Palazzo and Palazzo Bianco, named from their colors, both once belonged to the Brignole-Sale family, and were presented by members of it to the city. The former contains a library and a picture gallery, the latter is a museum. Their valuable works of art and books were largely the gifts of the same family.

Some of the finest of the palaces are still the homes of the nobility, and some of them the public is allowed to visit. It was our good fortune to spend part of a forenoon in one of the most beautiful—the Palazzo Marcello-Durazzo—in the company of an Italian gentleman who is familiar with its treasures. Ringing at the massive door, we were admitted to a wide court and conducted by an attendant up the magnificent staircase of Carrara marble. As we passed a doorway on the second floor, the man told us that the marquis, who is the present head of the family, is 92 years old; that he was at home, and we should therefore see only the public rooms. These we found princely in their furnishing and decoration. The mosaic floors and frescoed ceilings and rich tapestries are the setting of sculptures and paintings of rare value. Rubens and Van Dyck both lived in Genoa for a time, and both executed portraits of a number of members of the Durazzo family, and other fine examples of their work are here. A portrait by Rubens of himself, and a full length one of Philip IV., of Spain, are among the best. The Van Dycks are scattered about, but the most interesting ones to me are in the same room; the largest is the full-length portrait of the first lady in the Durazzo family born in this house. She is rather fair, has an attractive face, wears a simple but rich gown, and is sitting in an easy chair. Two little children stand beside her. They have the peculiar life-likeness and charm which Van Dyck knew so well how to put on to canvas when he painted a child. There are at least three other children's pictures in the room by him, of rare beauty. For one of these, a boy in white, the marquis has had large and urgent offers from America, we were told. Guido Reni painted one of the Durazzo family, and there are other specimens of his work. Strozzi, Andrea del Sarto, Tintoretto, and Titian are among the other great artists whose paintings lend value to the collection. Most of the pictures are set solidly upon the walls, as if made for the particular place they occupy; a few are placed in such relation to a mirror that they can be best seen by reflection.

It was in this palace that Napoleon I. lived during the battle of Marengo, and a magnificent gilt clock, vases and candelabra, his gift to the family, adorn one of the most elegant rooms. Four very beautiful chandeliers of Venetian glass adorn a large apartment, while in another hangs a single chandelier of immense size, its frame gilt and its pendants all of rock crystal in a variety of forms. One of the most remarkable objects shown is a framed mosaic, standing on an easel. It is, I should say, about two and a half feet long by one and a half broad. It represents a lion sitting in front of his den. The stones are all shades of gray, but so perfect are the shading and perspective that the animal looks alive, and at the right distance one seems to see far into the cave. It is the work of a Venetian artist who spent eight years upon it, and was blind when it was finished. A beautiful sedan chair covered with rich velvet looked too new to be an antique, and the attendant told us that it is still sometimes used in these streets where other vehicles cannot pass.

A step from this elegant home is the more modest palace occupied by the university. It has a large court and very fine staircase, but the foul odor which came to us as we ascended it suggested all too strongly that spotless marble may cover without concealing an enemy as dangerous as those which these strong walls were built to guard against. We looked into some of the class-rooms, finding them small and primitive in their appointments, cursorily inspected the physical laboratory, and spent some time in the faculty hall. Here are marble busts of Victor Emmanuel and his father, Charles Albert, also one of Mazzini, who was a student of the university. A large fresco in the center of the ceiling represents Columbus as a youth receiving a geography lesson from an old man. Set in the walls are some remarkable bronze reliefs of the passion of our Lord.

On the stone floor in front of the platform lay the remains of some burned paper—there had been a fire large enough to kindle a whole American village; but all it had done here was to burn the votes cast at an election held in the room the day before. It was hard to leave this interesting room, but harder still to get away from the charming botanical garden, which is a most valuable adjunct of the department of botany. It is arranged in an ideal way on terraces, at perhaps four different levels, suggesting at once the horizontal zones of vegetation. The high walls which partly inclose the grounds are covered with ancient ivies and beautiful clematis. The greenhouses contain, among other things, hundreds of ferns, from the fine maiden-hair of our woods to the giants of the Brazilian forests. Among the trees most interesting to us were the camphor and clove, their leaves, when crushed, yielding the odor of the gum and fruit. The magnolia grandiflora in this climate is magnificent. The leaves are large and a rich glossy green on the upper side, while the under side is russet brown. The white blossom is very large and most beautiful before fully open. The most curious plant, perhaps, which we saw was what is called the Paul and Virginia umbrella plant, a native of the Cape of Good Hope. It bears at the top of its single stalk, side by side, two large umbrella-shaped leaves. This university, one of the minor ones of Italy, was begun as a Jesuit college in 1623, and became a university in the early part of this century.

A drive to the Campo Santo, the remarkable cemetery laid out in 1867 on the hill side and in the valley bordering the Bisagno, takes one through a poorer part of the city, out under one of the old gateways, through streets where the life of the humblest can be seen. The houses are all high and have the green blinds, from almost every one of which clothing was hanging. It seems that no drying place for clothes is provided, so that the family washing has to be done two or three garments at a time and dried in this way. In some places by the roadside, where lay a bed of stones, we saw washing laid upon them. These small broken stones were being sifted at some points; the finest screenings are used for fertilization.

This is an economy as strange to our eyes as another we noticed on the same drive. This was the pressing of the refuse chippings of leather from a tannery. They are made into small blocks, dried in the sun and used for fuel.

We have since seen blocks of coal dust used on locomotives with such names as "Virgil" and "Saint Peter."

At the cemetery we left the carriage and walked through a part of the long arcades which contain rows of sarcophagi. Many of the monuments are imposing. One of the most beautiful is that to the memory of Marchese Taliacarne, minister plenipotentiary to Portugal. The life-size figure of an angel in Carrara marble is very beautiful; the marble is so worked as to give the effect of satin texture to the garments, and of feathers to the wings. Nowhere have I seen the possibilities of white marble better brought out than in the monument to Enrico Amerigo, the administrator of an institute for the blind. Two blind children, a half grown boy and a little girl, stand on the steps; the infirmity is as plainly shown on the face of the boy, in the lines of the marble, as I have seen it on a living face. Many of the monuments seem to consist of statues of the remaining members of the family, or of a husband and wife alone, who are represented in attitudes of grief. The prevailing style of dress has frequently been copied, so that the beautifully wrought Carrara reminds one of an old fashion plate. There could hardly be found better evidence that a perfectly simple robe is the only one that will never lose its beauty. Some of the most costly monuments have black and white marble combined with very startling effect. The Carrara family have, for their monument, bronze figures against black marble. There are two rows of these immense arcades, one above the other, built partly around the level portion of the cemetery; in the center of the upper row, at a great height, is a large rotunda, used as a chapel. At the back rise the mountains, as if to add to the impressiveness of the solemn camp.

On a bright morning we went outside the city walls again, this time to visit the Villa Pallavicini at Pegli, a little watering place on the Riviera. From the town, which lies close to the sea, we walked up a broad avenue to the entrance of the villa, where guides wait to show strangers about. A fee is charged and the proceeds given to the poor. The family was not at home and we were not taken into the large house, but for two hours we were conducted about the grounds, the beauty of which I can but faintly describe. We were led around to the rear of the villa, where we had a view of the very broad, beautiful Carrara marble steps which lead to one of the entrances; we passed the Gothic chapel and soon came to a little one roomed building, erected in memory of a visit made to the place by Maria Theresa, the mother of Victor Emmanuel. It is a gem of a room, decorated in Pompeiian style. Passing through it we came out into a broad avenue lined on both sides with large vases; each of these contained an orange tree with its golden fruit. At the other end of this avenue is a white triumphal arch with beautiful figures upon it, and this inscription on its facade:

"Valete-urbani-labores,
Valete-procul. anima-impedimenta,
Me-supera-convexa-et sylvae-et fontes,
Et-quid est altiora-loquentis naturae.
Eve hat-ad Deum."

Was ever a more beautiful explanation of a country home given?

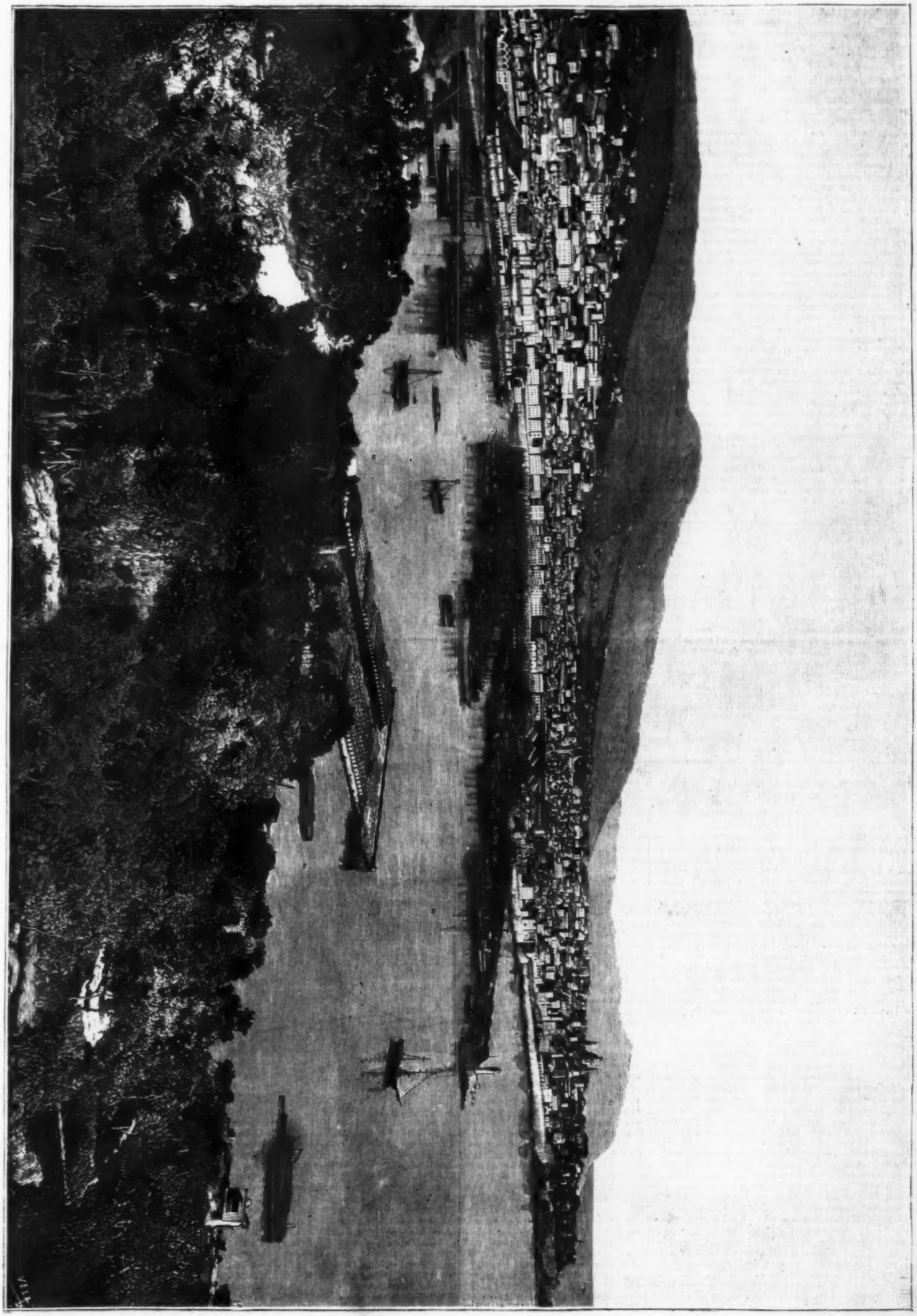
Passing under the arch, we came with a few steps to a low, rough house, with mossy roof, overhung with tall pines and hemlocks growing on fern-clad hill sides. From near this point we had a fine view of the hill sides below us and the valley, all covered with vineyards and cultivated fields, belonging to the estate.

Continuing our walk along the well made, always ascending path, we came to a grove of giant palms, some of them date palms; on the other side, tall bamboos, and great, clumsy cacti, with their yellow blossoms standing on the top of the leaf. Near at hand is a large cork oak, and just beyond it a magnificent view of the mountains, across the valley of Varena. Winding always up the hill, past camphor and cinnamon and pepper trees, with tall umbrella pines towering above us, with an endless variety of rare and beautiful plants beside the way, we come up to a summer house, where there is a still more beautiful view than any we have had, for this includes a wide expanse of the Mediterranean, with the mountains at the left stretching into its waters, and the sails of many boats upon it. We thought nothing could be more interesting than what we had seen, but we were close upon another surprise—a grotto. We went single file through winding passages, so dark that our guide lighted matches, out into a good sized grotto, its walls supported by columns and beset with stalactites and stalagmites. This is an artificial cave, but so perfectly has it been made, that it shows not a trace of man's hand. From the central part of the grotto we catch sight of a boat, through an archway, and a moment later we are led to an opening, where another is waiting to take us in. It is rowed by the quaintest of old men. In and out we pass among the rocky passages, still within the grotto, until suddenly we emerge into daylight, and find ourselves on a little pond, beset with flower beds, and in its center a little temple of Diana, on a tiny island.

On the edge of the lake an imitation of an Egyptian obelisk, hieroglyphics and all, has been placed. Not far from this is a Turkish kiosk, from which there is another lovely view of the sea. To add to the succession of surprises, so wonderfully arranged that the stranger has no hint of them, he is led now into a rose bower, and finds the finest of spray is coming upon him from above, or he is enticed to take a seat in a swing, only to have another shower bath; or he gets one from a little maze which he is induced enter by the guide, who probably gets amusement enough out of the surprise of each party in this unusual display of water works to last him till the next one comes.

It was easy to believe, when we had made our survey of the place, that it took eight years to lay out and arrange these grounds and build the house, and that 400 people were engaged in doing it. It was begun in 1828 by a Marquis Durazzo, a member of the same family whose villa in the city I have described. He married a daughter of the Marquis Pallavicini, and it is by her name that the villa is best known. The house was enlarged and adorned in 1848. A daughter of the founder of the place now occupies it.

A member of our party, who has visited some of the



GENOA.—(From a Photograph.)

finest estates of the English nobility, told me, that while these are on a grander scale, the marvelous situation of this place gives it advantages of variety in arrangement and landscape which she has not seen in England.

Our two days and a half in Genoa, full of pleasure as they were, served, perhaps, more than anything else to make us wish for weeks there. A. D.

THE ÆPYORNIS.

It is now many years ago that we announced the publication of the first volumes of the *Histoire Physique, Naturelle et Politique de Madagascar*. Since then this great work, of which Mr. Alfred Grandidier collected the first materials and to which he has devoted his life, has been carried on without interruption, and already constitutes an incomparable scientific monument. No region of the globe will have been as well studied as Madagascar, and none is worthier of being the object of thorough investigation. This great island, which probably formed part of a much more extensive continent on the east coast side, possesses, in fact, a fauna and flora of a very peculiar character. Along with types that we meet with nowhere else, we find animals here whose analogues do not exist in Africa, which, nevertheless, is separated from Madagascar only by the Mozambique Channel, nor upon the Mascarenhas, Seychelles and Comoro Islands, but in southern or insular Asia, or, at a greater distance still, in New Zealand. Thus, to mention but a few examples taken from the higher animals, the monkeys, so widely distributed in the great forests of the African continent, are not found at all in Madagascar, but are replaced there by lemurids or false monkeys, which present themselves under the most varied forms, while there are but few species, and these of small size, in equatorial Africa and in Malaisia. The woodpeckers, which are disseminated in the cold, temperate and tropical regions, are wanting in Madagascar. The hornbills, those odd birds whose bill is surmounted with an extraordinary protuberance, which is sometimes as large as the bill itself, the barbets, which owe their name to the stiff hairs with which the base of their bill is provided, the colions and the touracos, do not exist in Madagascar; but, as an offset, there do exist couas and a whole series of most remarkable sparrows, Euryceres, Falculies, etc. Some of the sparrows have an Indian or Malaisian physiognomy, while others are very closely connected with certain paradise birds of New Guinea called *Astrapia*, and others,

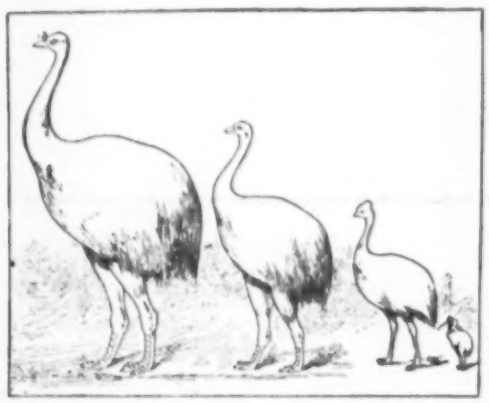


Fig. 1.—Relative Sizes of (1) Æpyornis ingens; (2) Æ. Mulleri; (3) Helmeted Cassowary; and (4) Apteryx of New Zealand.

again, like the Vangæ and the Xenopirostres, approach the Australian cassicans and the Clytorhynci of New Caledonia. So, too, certain pigeons of Madagascar are connected with a family of which we find a few representatives in the south of Asia, but which reaches its greatest development in New Guinea, the Moluccas and the different archipelagos of Polynesia. Finally, if we no longer consider the contemporaneous fauna only, but examine the ancient fauna of Madagascar, we shall discover still more extraordinary affinities between the ornithological population of this great island and that of New Zealand.

Our readers are aware of the fact that in New Zealand there exist some odd birds that are called apteryxes, and that they belong to the same order as the ostriches of Africa, the nandus of America, and the cassowaries and emus of Australia and Papuasia; but which are of much smaller size, scarcely exceeding that of a hen.

Speaking of the apteryx, there are other birds almost deprived of wings, and other brevipennates that provisionally inhabited of old the same country as the apteryxes, but which, as compared with the latter, were true giants. These birds are the moas (*Dinornis*), whose accumulated bones are sometimes found in considerable quantity in the superficial strata of the earth of New Zealand, and of which twenty species have been described by Mr. Richard Owen and Mr. J. Von Haast.

The largest was the *Dinornis maximus*, which was about 3·5 meters in height. Finally came the other species, forming a descending series, whose last term remained still larger and heavier in form than the apteryxes. Of these different species, some exhibited in the general aspect of their skeleton resemblances with the ostriches, the nandus, the cassowaries, the emus, or even with the ancient pigeons of Mauritius Island, and with the dodos; others were characterized by their lank form, and others, finally, had heavy and massive legs and elephant's feet. Some had but three toes, like the cassowaries, while others, on the contrary, were provided, like the apteryx, with a more or less developed posterior toe; but whatever their general form or their dimensions, all these birds had a relatively shorter and stronger metatarsal bone and thicker toes than the apteryxes. Their bill, instead of being elongated like that of a woodcock, was short, widened at the base and slightly more recurved, with the upper edge continuing the line of the forehead, where nothing indicated the presence of a horny crest analogous to that of the cassowaries.

The sternum, as in the apteryxes, was in the form of a shield, widely notched at each side upon its lower edge, and scarcely elevated in the center in its upper portion. This absence of median keel, the feeble development of the coracoid bones in the rudimentary state of the humerus, which was reduced to a simple rod, indicate an animal almost devoid of wings. In this respect the dinornes were as homely as the apteryxes, and as they were still heavier than the large running birds of the present epoch, and as they were confined on two islands of a relatively limited extent, they were fatally doomed to disappear.

What caused their extinction and at what epoch did it occur? This is a question that has much occupied naturalists. The bones of the moas sometimes repose in marshes, but are oftener found in caves or in the midst of deposits analogous to the kjækkenmøddings of Southern Europe, that is to say, amid kitchen refuse, bones of sea birds and of otaries, mingled with

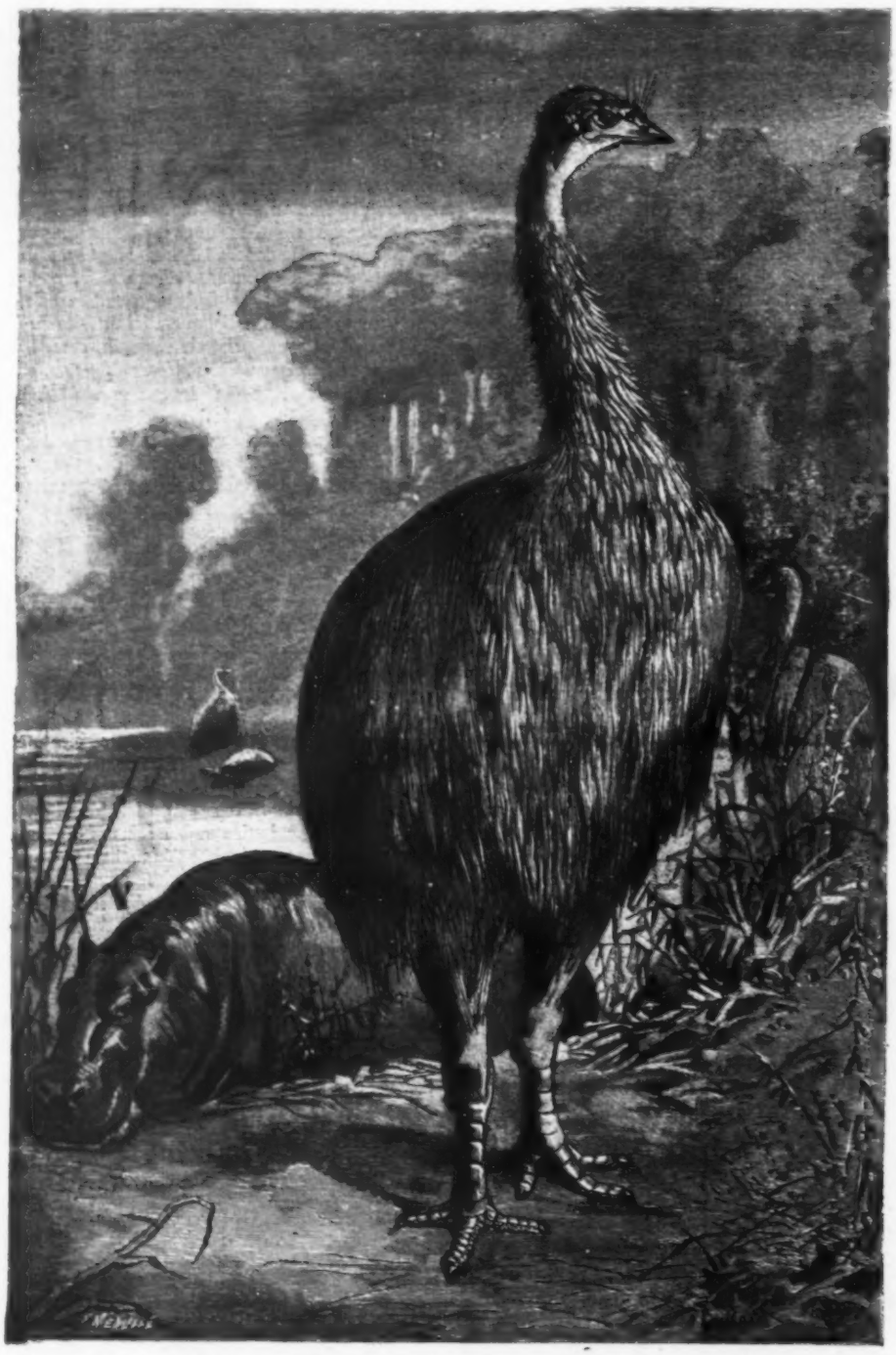


Fig 2.—RESTORATION OF ÆPYORNIS INGENS, OF MADAGASCAR.

clumsy instruments of silex, sandstone or other silicious rocks, and sometimes the stratum that incloses them is covered with a bed of sand or vegetable mould 15 or 20 centimeters in thickness. It is therefore evident that if not all the dinornes, at least some of them were hunted by man and were used as food by him. In Mr. Von Haast's opinion the moa hunters of New Zealand were the contemporaries of the prehistoric men who in our country hunted the mammoth, while in the opinion of Messrs. Mantell and Quatrefages they belonged to the Maori race. In other words, to some the moas were exterminated at the end of the quaternary epoch, or at the opening of the modern period, while to others they lived up to an epoch closely bordering upon our own. We know positively, in fact, that the Maoris, who are true Polynesians, did not land in New Zealand until the first part of the fifteenth century, whither they came from Rarotonga Island, one of the islands of the Cook archipelago. The Maori songs that have faithfully preserved these traditions teach us, moreover, that the majority of the immigrants found the country absolutely deserted, and that a single one of them met with a few aborigines at a point of New Zealand. Now, it results from various anthropological researches that these aborigines, traces of whom are still found, were Papuans, that is to say, other colonists who had reached the country in small numbers, and likewise by way of the sea, some time before the Maoris, and not the remains of an autochthonous population dating back to prehistoric times.

The testimony of an old Maori chief, the traditions preserved in aboriginal songs collected by Sir George Gray, and the very conditions in which some bones, eggs, and feathers, even, of *Dinornis*, appear entirely favorable to the theory maintained by Messrs. Quatrefages and Mantell. However, as the remains of the large species of *Dinornis* are wanting in the kjækkenmøddings of New Zealand, it may be that these birds disappeared at a date a little more ancient than the species of smaller size.

The facts that we have just recalled are not as foreign to our subject as they might seem at first sight. They, in fact, throw a strong light upon the history of other brevipennate birds that lived in Madagascar in olden times, that played the same role in this island as the dinornes in New Zealand, and that became extinct, if not at the same epoch, at least under the same conditions.

Sixty years ago, Mr. Sganzin, a traveler in Madagascar, sent to Jules Verreaux, who was then at the Cape of Good Hope, an outline sketch of a gigantic egg, with the statement that he had seen two similar eggs, one of which was sawed in two, and the other was traversed by a stick lengthwise, so that it could be used as a mortar for crushing rice. This sketch and these notes were unfortunately lost in the shipwreck that swallowed up the collections made by Verreaux in southern Africa; but some time afterward (in 1834) Goudot, another traveler, collected in Madagascar some remains of egg shells that Mr. P. Gervais took occasion to speak of in the article on Austria in the "Dictionnaire de Sciences Naturelles," and that he referred to as comparable with the eggs of the African ostrich as regards size. Later still (in 1848), Mr. Dumarele saw at Port Leven, upon the northwest coast of Madagascar, an egg that the inhabitants used as a water vessel, and that had a capacity of thirteen bottles; but it was not till 1850 that Mr. Abadie, a captain of a merchant ship, furnished a serious basis for the studies of

naturalists by bringing to France not only a certain number of absolutely intact eggs, but some bones of a gigantic bird found near the port of Masikoro, in the south of Madagascar. These eggs and bones were presented to the Academy of Sciences on the 27th of January, 1851, by Isidore Geoffroy Saint-Hilaire, who did not hesitate to attribute them to a species of brevipennate, for which he proposed the name of *Æpyornis maximus*. Soon afterward, other fragments of bones, and some eggs entire or broken, were collected in Madagascar by Mr. Coquerel and by Mr. Grandidier. Finally, in 1869, this last named naturalist succeeded in obtaining much more important pieces under conditions that merit being recalled.

Mr. Grandidier, desirous of a plan of a locality on the west coast, a revenue farmer was intrusted with the operation, and to this effect had put up a white cloth to serve as a datum point. But he had not reckoned upon the superstitious spirit of the Malgaches, who, persuaded that this cloth would cast a spell upon the country, resolved to do the revenue officer harm and seize his cargo, which was worth more than 28,000 francs. Forewarned of what was in the wind, Mr. Grandidier went at once to the residence of a chief and succeeded in bringing him to reason and in persuading him to give orders immediately that the man should not be molested.

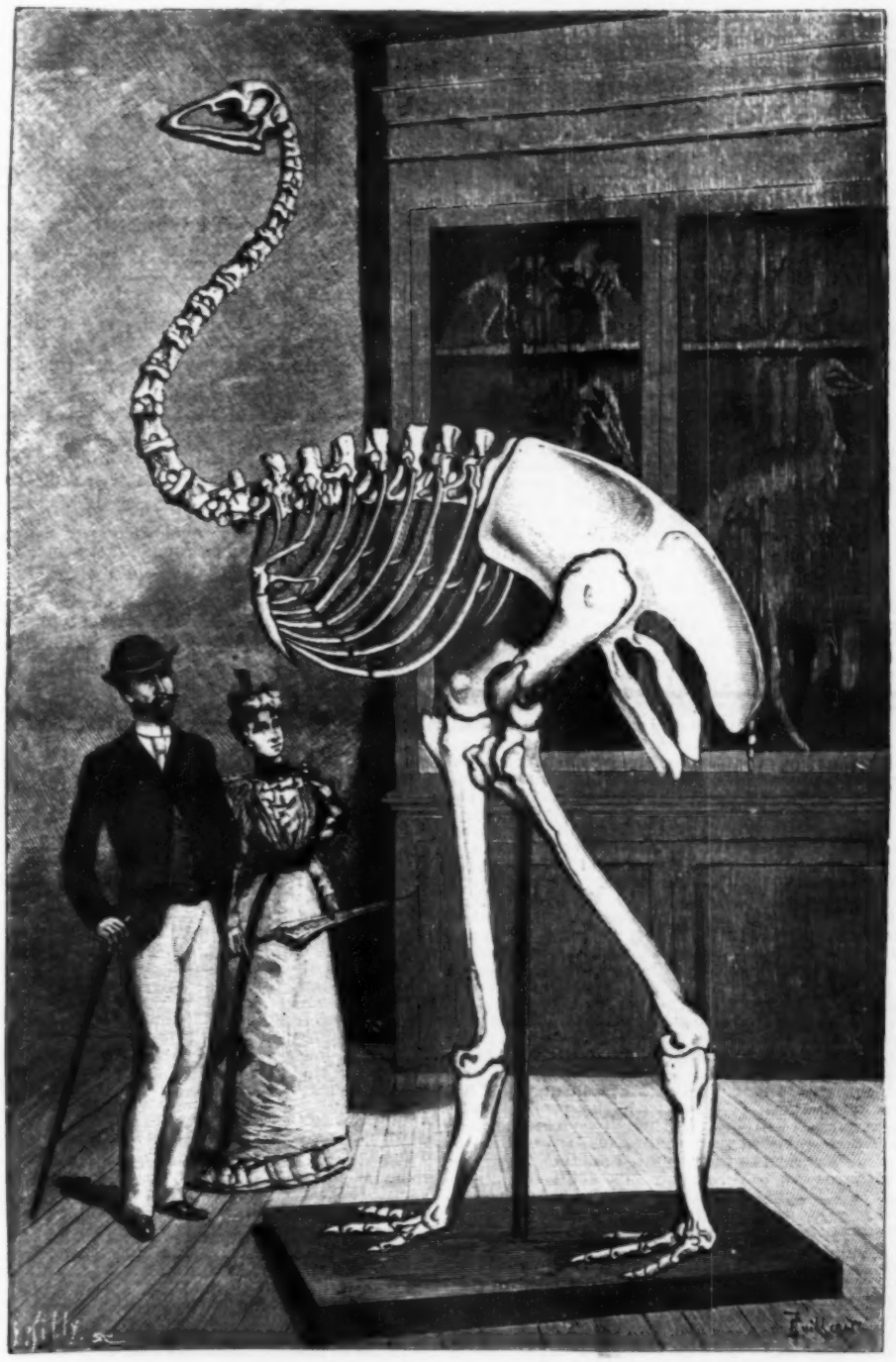


FIG. 3.—SKELETON OF ÆPYORNIS INGENS, OF MADAGASCAR.

This matter having been settled, Mr. Grandidier began to talk with the chief about the natural productions of the country, and was led to ask him if he knew anything about the animal designated by Flacourt as the *vouron patra*. "No," said the chief; "I have not seen it myself, but my ancestors have, and the proof that I am not lying is that I have found its bones in digging a pond to water my oxen." Mr. Grandidier immediately asked to see these bones. "Impossible," said the chief; "they are the bones of the god of the pond." However, he finally consented upon the offer that was made to him of an ox to be sacrified to appease the anger of the god. The price of the victim having been paid to him in piasters and gunpowder, Mr. Grandidier was enabled to proceed to the Amboulitsate pond, whence he took some huge bones with which he loaded a canoe. In this find there figured a complete tibia 64 centimeters in length, various fragments of the same bone, a nearly entire femur, 32 centimeters in length, two isolated vertebræ and several femurs some entire and others broken, apparently belonging to two species of smaller size than the one to which the tibia, the first femur and the vertebræ belonged. They formed the subject of a very important memoir that Mr. Milne-Edwards and Mr. Grandidier published in 1869, and in which these naturalists demonstrated that the 32 centimeter femur and the 64 centimeter tibia should be attributed to one and the same bird, and that the latter belonged to the very same species described by Saint-Hilaire under the name of *Æpyornis maximus*, and of which Mr. Leinard had sent a more complete fragment of a foot bone to the museum than the specimen collected by Mr. Abadie. Afterward, discussing the affinities of this species, Messrs. Milne-Edwards and Grandidier proved that Saint-Hilaire was not mistaken in his diagnosis, and that the *Æpyornis* was indeed a brevipennate—a bird of the same order as the *Dinornis* and the *Apteryx*, and not a penguin or an auk, as had been supposed by Mr. Valenciennes, or a large bird of prey, as had been claimed later on by Mr. Bianconi, in whose opinion the gigantic bird of Madagascar was the famous roc or ruc mentioned by Marco Polo.

Saint-Hilaire had recalled, moreover, that the roc, which is likewise mentioned in various oriental works, was not given by Marco Polo as a Malgash bird, but as one that inhabited "a few other islands beyond Madagascar, upon the south coast." Finally, on placing the foot bones of the *Æpyornis maximus* in their normal position, Messrs. Milne-Edwards and Grandidier found that the dimensions of this species had been notably exaggerated. The dorsal region of the bird probably rose to no more than 1·45 meters above the ground, and as the length of the neck is usually proportionate to that of the legs, the total height from the foot to the top of the head could scarcely have been more than two meters. Consequently, far from exceeding the *Dinornis maximus*, as Mr. Bianconi supposed, the *Æpyornis maximus* was scarcely any larger than an ostrich, but it was more squat and massive. Behind it came the two other species, *medius* and *modestus*, the bones of which likewise were found by Mr. Grandidier in the Amboulitsate pond. The last was nearly of the size of a bustard. For his part, Mr. G. D. Rowley, on studying the different eggs of *Æpyornis*, reached the conclusion that they belonged to at least two species—*maximus* and *Grandidieri*.

Very recent discoveries, in confirming the perfect accuracy of the views of Saint-Hilaire and Messrs. Milne-Edwards and Grandidier, have permitted of adding still other species to those just mentioned. In the latter part of 1893, the Museum of Natural History, of Paris, received, in fact, a magnificent series of *Æpyornis* bones. Some were discovered upon the west coast, between Belo and Mouroundava, by Mr. Greve; others from the southwest were sent by Mr. Samat, a merchant at Mouroundava; others are due to Mr. Emile Gautier; and finally, others, and these are the most numerous, were collected at Antsirabe, in the very center of the island, by Mr. George Muller. Through these materials, it will soon be possible to exhibit in the galleries of the museum some *Æpyornis* skeletons as complete as those of the *Dinornis;* but, in awaiting this practical result, it has been possible to formulate some scientific conclusions of the highest interest. Thus, Messrs. Milne-Edwards and Grandidier have recognized in the collections of Messrs. Greve and Samat, alongside of numerous bones of the species recently described by Mr. Andrews under the name of *Æ. Titan*, some bones of much larger size belonging to a new species that they have named *Æ. ingens*. This species, of which we give herewith two figures representing, one of them, the skeleton and the other external aspect of the bird such as it may be imagined, much surpassed in size *Æ. maximus*, and was more than three meters in height. The femur, in particular, made itself remarked by the thickness of its body, the circumference of which was 29 centimeters, while in a large sized ox the corresponding portion of the same bone measures but 18 centimeters. The tibia was likewise of extraordinary power, and the bone of the foot, 42 centimeters in length, widened out considerably toward the portion to which the toes were attached. The remains of the *Æ. Titan* and *Æ. ingens* were accompanied with those of two other species up to then unknown to naturalists—the *Æ. cursor*, nearly equaling the *maximus*, but offering a slimmer form, and *Æ. lentus*, recognizable, on the contrary, by its short and massive feet. On another hand, in the truly admirable collection made by Mr. Muller, at Antsirabe, figured in the first place the remains of a species smaller than the *Æ. Hildebrandii* described by Mr. Burkhardt from specimens derived from the same locality, and, in the second place, numerous bones of other brevipennates of medium size, less heavy in form than the *Æpyornis*, and more nearly approaching cassowaries. These birds, which Messrs. Milne-Edwards and Grandidier have proposed to call *Mullerornis*, were represented in Madagascar by at least three species—the *M. Betsiloei*, of Antsirabe, the *M. agilis*, of the southwest coast, and the *M. rudis*, discovered by Mr. Greve in the deposits of the west coast.

As we have just said, we now possess nearly complete skeletons of the *Æpyornis*, and know that these brevipennates differed from the *Dinornis* in their head being longer, narrower, and less flattened in the cranial region, where a more highly developed brain found lodgment. Their bill, in form, recalls that of the nandus. Their wings were absolutely rudimentary. Finally, their huge legs were not as heavy as one might suppose, since the femur at least received air in its interior, and this permits of the belief that the thoracic cage was not closed beneath by a diaphragm as in the apteryx, and that the aerial sacks must have been as well developed as in the ostrich and cassowary. They were, therefore, capable of running upon the ground with a certain rapidity, especially the species of *Mullerornis*, whose legs were more slender than those of the species of *Æpyornis* properly so called.

All these birds lived upon the border of lakes and ponds, and probably fed upon tender herbs and the roots of aquatic plants.

It was in the midst of herbage, or perhaps, rather, as Mr. Last supposes, upon the shores of the south and southwest, that the *Æpyornis* must have laid its huge eggs, of which the museum is now in possession of a fine series, but which were not so long ago so rare that they were sold in England at from $1,000 to $1,400 each. Most of those that appear in collections must have belonged to the *Æ. maximus*, that is to say, to the species which, as regards size, comes after *Æ. ingens* and *Æ. Titan*. They are, nevertheless, of huge dimensions, and, according to the calculations of Saint-Hilaire, equal to six ostrich eggs and 148 hen's eggs. However, if we consider their bulk not in an absolute manner, but with respect to the size of the bird, we find that they are relatively smaller than the eggs of the apteryx. The latter, in fact, while scarcely larger than a hen, lays eggs that are more elongated and almost as thick as those of the nandu.

The history of the great brevipennates of Madagascar exhibits, then, an extraordinary similitude with that of the great brevipennates of New Zealand. Both have been destroyed by man, although at different epochs, the species of *Æpyornis* having doubtless preceded those of *Dinornis* to the tomb. Both were represented of old by several species of decreasing size, and both, after occupying two continents, or perhaps two portions of the same southern continent, were relegated to lands of a more limited extent, where they finally succumbed.

The exceptional interest of the facts that we have just given will, it is hoped, excuse the length of this article. The accompanying figures are not imaginary ones, for the excellent artist who drew them took for his models the graphic restorations made by Mr. Milne-Edwards, and these restorations were obtained by putting in their natural situation the different parts of the nearly complete skeleton of an *Æpyornis Mulleri* and the principal bones of an *Æ. ingens*.—*La Nature.*

THE MAN-LIKE APES.

By R. LYDEKKER, B.A.Cantab., F.R.S.

THROUGH the generosity of the Board of Governors of the Cheltenham Hospital, the Natural History Branch of the British Museum has been recently enriched by a specimen of great historical interest in the shape of the skeleton of a young chimpanzee from Angola, which was dissected and minutely described so far back as 1699, by Dr. Edward Tyson, in a rare

work entitled "Orang-Outang, *sive* Homo Sylvestris," a copy of the volume being appropriately placed alongside of the skeleton in one of the bays on the left side of the great entrance hall. The work in question is the first account of a member of the group of man-like apes having any pretension to scientific accuracy; and the acquisition by the museum of the skeleton and the volume in which it is described may well serve as the text for a short account of the man-like apes in general.

That these apes are our nearest cousins is probably well known to all our readers; but the degree and extent of this relationship, as well as the characters by which it is displayed, are probably far less familiar to many of them. In the first place it will be noticed that we speak of this relationship as one of cousinship, and not of ancestry; and it is well that the reader should at once free himself from any idea that there is any vestige of direct ancestral kinship between these, for the most part, hideous creatures and himself. Such relationship as does exist—and we cannot but believe that such there is—is of a comparatively distant kind; and the common ancestor must have lived ages before the mammoth roamed over the plains and valleys of England, since at that date man was as distinctly differentiated from the apes as he is in the present century. Whether this "missing link" will ever turn up, or in what country it is most likely to have lived, are questions impossible to answer; but from the extreme rarity with which fossil remains of man-like apes are found in countries where they are known to have existed for long ages, and from the probability that the distributional area of the aforesaid "link" was extremely limited, we cannot give much hope that the researches of paleontologists will ever be rewarded by such a "find."

From their large bodily size, coupled with that terrible caricature of the human face and form characterizing the more typical representatives of the man-like apes, no one would have any difficulty in picking out these creatures from among their lower relatives. There might, however, be some hesitation with regard to the long-armed gibbons; and we, therefore, proceed at once to point out how the members of the man-like group may be distinguished as a whole from other monkeys.

We presume, in the first place, that all our readers are aware that apes, monkeys, and lemurs constitute one great mammalian order—the Primates; and likewise that lemurs differ from apes and monkeys by their long fox-like faces and immobile expression, to say nothing of many anatomical peculiarities into the consideration of which it will be unnecessary to enter on this occasion. Possibly we shall be presuming too much as to the extent of their zoological knowledge if we also assume that they are acquainted with the difference between the apes and monkeys of the Old World and the monkeys of the New; and it is accordingly advisable to make this clear at starting. The whole of the Old World representatives of the division of the order to which we are confining our attention are characterized by having teeth agreeing both in number and arrangement with those of man. Thus in all cases in each jaw there are two pairs of incisors, a single pair of eye teeth, tusks, or canines, and five pairs of cheek teeth, of which the last, or "wisdom tooth," is frequently very late in making its appearance, as shown in the lower jaw of an immature chimpanzee, in which it is still embedded in a cavity in the bone, the top of which is open. It is further essential to observe that of these five cheek teeth the first two on each side are simpler than the three hinder ones, and are preceded in the infant by milk teeth, whereas the latter have no such predecessors. It is accordingly the custom to call the two simpler teeth premolars or bicuspids, and the three more complex ones molars. If, now, we examine an ordinary American monkey, we shall find six cheek teeth on each side of both the upper and lower jaws, of which half are premolars and half molars, while in the marmosets, which constitute a second American family, although the total number of cheek teeth is the same as in the Old World forms, yet the proportion is different, there being three premolars and two molars. It may, therefore, be concisely stated that all American monkeys differ from their Old World cousins in having three instead of two pairs of premolar teeth, whence it may be inferred that they belong to a lower and more generalized type, there being a universal tendency throughout the higher vertebrates to a diminution or disappearance of the teeth with the advance of specialization. In the marmosets the loss of the last molar is unique in the higher division of the order, and is indeed a somewhat remarkable peculiarity to occur in a herbivorous mammal, among which the reduction is usually confined to the front and premolar teeth.

As the teeth serve most readily to differentiate the Old World monkeys from their American allies, so the man-like apes are sharply distinguished from their relatives by the conformation of these organs. The molar teeth of the man-like apes closely resemble our own, having the angles of their crowns rounded off, and carrying on their grinding surfaces four very blunt tubercles, placed alternately to one another, as well as a somewhat smaller tubercle at the hinder end.

On the other hand, in the monkeys the molar teeth are oblong in form, and carry four very prominent tubercles arranged in pairs at the two extremities of each, and each pair being connected so as to form a couple of more or less well defined transverse ridges extending right across the crown. Then, again, whereas in the man-like apes the last molar or "wisdom tooth" in the lower jaw is similar in form to the two teeth in front of it, in the great majority of the Old World monkeys this tooth has a large projecting heel at its hinder end. These dental characters afford very important evidence of the close kinship of the man-like apes to man himself, and undoubtedly outweigh the difference in the form of the whole dental series now to be noticed, which is largely due to adaptation. In both the upper and lower jaws of man, the teeth, as we all know, are arranged in a regular horse-shoe series, with scarcely any interruption to the continuity by the tusks, which are but little taller than the other members of the series. In the adults (and especially the males of the larger species) of the man-like apes the cheek teeth are arranged in a nearly straight line and form a more or less angulated junction with the line of the incisors; the large tusks occupying the angle between the two series, and thus forming a marked break in continuity. In these respects the man-like apes resemble their inferior kindred. If, however, we take a young individual of the larger anthropoids, and especially the chimpanzee, it will be found that the teeth, owing partly to the imperfect protrusion of the tusks, form a much less interrupted and more regularly curved series. Indeed, with the exception that the whole jaw is longer and narrower, and the partially protruded tusks are proportionally larger, the characters of the figured specimen make a very marked approximation to the human type; and the jaw of a chimpanzee at this stage may be regarded as almost intermediate in structure between that of man and that of an adult male gorilla. Moreover, in this juvenile state the bony union of the two branches of the lower jaw partakes of the short and rounded form characterizing that of man; whereas in the adult it becomes longer and more deeply channeled, like that of the lower monkeys. In many respects the teeth and jaws of the gibbons, or smallest representatives of the group under consideration, conform to the intermediate type. Not only are the human characteristics most developed in the teeth and jaws of the young of the larger man-like apes and the gibbons at all ages, but the same is true with regard to the skull of the former. The skull of the young gorilla, for instance, lacks the beetling crests over the eyes and the prominent ridge down the middle of the crown which give such a forbidding and repulsive aspect to the cranium of the full grown male. This loss of human resemblances is due to specialization taking two different lines in man on the one hand and in the larger man-like apes on the other; the development in the one case tending to increased size of brain, coupled with no marked increase in the size of the tusks, while in the other the brain grows at a less rapid rate, and the skull and tusks (more especially in the male) assume characters approximating them to those of the inferior animals. Both in men and apes the young condition may accordingly be regarded as the most generalized.

Among the other features in which the man-like apes differ from monkeys and resemble man are the absence of dilatable pouches in the cheeks for the storage of food, and the total loss of the tail, as well as the flattened, instead of laterally compressed, form of the breast bone; the gibbons alone retaining the naked patches on the buttocks so characteristic of the monkeys, but only in a much reduced condition. The gorilla and chimpanzees further differ from the other members of the group, and thereby resemble man alone in the loss of the so-called central bone of the wrist—a bone occupying a nearly central position between the upper and lower rows of small bones of which that joint is composed. What may be the object of the disappearance of this bone it is not easy to say; but the fact that it is wanting in the two genera of apes just mentioned is very significant of their close structural affinity with man. In one respect the man-like apes stand apart both from the human and the monkey type, namely, in the great relative length of the arms as compared with the legs, the disproportion being most strongly marked in the gibbons, which are actually able to walk in the upright posture with their bent knuckles touching the ground.

So far, indeed, as their bodily structure is concerned, the man-like apes seem undoubtedly more nearly related to man than they are to the lower monkeys; and they constitute a family (*Simiida*) by themselves, which may be regarded as intermediate between the one (*Cercopithecidæ*) including the lower monkeys and that represented by man himself. While at present, as we have said, the "missing link" between man and the apes is wanting, extinct forms tend to connect the latter very closely with the monkeys. For instance, a fossil ape (*Dryopithecus*) from the Miocene Tertiary strata of France has the bony union between the two branches of the lower jaw much longer than in any existing man-like ape, although it is approached in this respect by the gorilla; while from the corresponding beds of Italy another extinct form (*Oreopithecus*) appears to be in great part intermediate between the man-like apes and the lower monkeys. It may be mentioned here that in the same strata in which occur the remains of the dryopitheeus are found flint flakes which have been regarded as exhibiting signs of artificial chipping, and the extinct ape in question has consequently been credited with the production of these supposed weapons. Although we have not seen these wonderful flints, we confess ourselves to be as skeptical in regard to their reputed manufacture as we are with respect to Prof. Garner's ability to understand "ape language."

The present distribution of the anthropoid apes clearly points to the existing species being the last survivors of a group which was once widely spread over the Old World, when warmer climatic conditions prevailed over what we now call the temperate regions. The gorilla, for instance, is confined to western equatorial Africa, where it is accompanied by the two species of chimpanzee, one of which ranges eastward across the continent as far as Uganda.

The orangs, of which there are probably two species, on the other hand, are confined to the great islands of Sumatra and Borneo; while the numerous species of gibbons have a wide range in southeastern Asia, attaining their maximum development in the Malayan Archipelago and the adjacent regions. This distribution is remarkably discontinuous, but the little that we at present know of the past history of the group tends somewhat to consolidate the scattered distributional areas of the group. One of the most noteworthy of such paleontological discoveries is the fact that a chimpanzee once inhabited northern India; while it is most probable that an orang also was a contemporaneous dweller in the same country. This suggests that India may have been the original home of the larger man-like apes; from whence the chimpanzees and gorillas migrated southwestward to equatorial Africa, while the orangs traveled in an easterly direction to find a last home in the tropical islands to which they are now confined. This probability, that India was the home of the larger members of the group during the later Pliocene period, further suggests that it is on that country we should concentrate our hopes of discovering the "missing link;" and it is not a little noteworthy that, so far as the very fragmentary specimen by which alone it is known admits of our forming a judgment, the Indian extinct chimpanzee appears to have approached nearer to the human type than do its living cousins. During the earlier Miocene epoch, as we have seen, an extinct genus of large man-like apes inhabited western Europe, which, during the commencement of the Pliocene period, was likewise the home of a species of gibbon.

Of the four existing genera of the man-like apes, the chimpanzees (*Anthropopithecus*) are clearly those which come nearest to man, this being especially shown by the shortness of the bony union between the two branches of the lower jaw, the form and mode of arrangement of the teeth (especially in the young), the relatively small development of the tusks of the male, the absence of the enormous bony crests on the skull so characteristic of the gorilla, and the slight difference in the size of the two sexes. The specimen shown in Mr. Ranyard's photographs is a female recently acquired by the Zoological Society, whose amiable disposition and general intelligence promise to make her almost as popular as the deceased "Sally."

The chimpanzee and the gorilla alone resemble man in having seventeen vertebræ between the neck and the sacrum, and likewise in the absence of the central bone in the wrist, although they differ in the comparatively unimportant feature of possessing an additional pair of ribs. In addition to the characters already mentioned, the gorilla (*Gorilla*) differs from the chimpanzee in the more oval contour of its brain, thereby approximating more nearly to the human type.

The reduction of the number of vertebræ between the neck and the sacrum to sixteen, together with the retention of the central bone in the wrist, the great length of the arms, which in the upright posture reach to the ankles, and the peculiar upward prolongation of the vertex of the skull, serve at once to show that the orangs (*Simia*) stand on a lower evolutionary platform than either of the preceding representatives of the family. Externally they are further distinguished by the rudimentary condition of the great toe, the peculiarly flattened form of the almost disk like leaden-hued face of the adult, and the red tinge of the long and shaggy hair, the latter being in marked contrast to the black hue of the gorilla and chimpanzees. Although in possessing only a dozen pairs of ribs the orangs differ from both the latter and resemble man, yet this resemblance is greatly outweighed by the difference in the number of the vertebræ.

Agreeing with the orangs and the lower monkeys in the presence of a central bone in the wrist, the gibbons (*Hylobates*) make a further approximation to the latter in the retention of small naked callosities on the buttocks; while they are likewise distinguished by their small size and the inordinate length of their arms, which, as already said, admit of the bent wrist being applied to the ground when the animals are walking in the upright posture. Another characteristic of the gibbons is the smooth contour and relatively large size of the brain case of the skull, which gives them a more human-like physiognomy than the adults of their larger relatives; this does not, however, by any means imply that the brain power of these creatures is greater, but is merely due to the circumstance that in any group of animals the relative size of the brain is necessarily larger in the smaller forms. In color gibbons are subject to considerable variation, the Hainan species being uniformly black, Muller's gibbon brownish-black and gray, with a whitish circle round the face; while the silver gibbon takes its name from the uniformly silver-gray hue of its pelage. Gibbons are the only apes which habitually walk in the upright position, and although they frequently aid themselves by applying the hands to the ground, they often while walking clasp them together at the back of the head. In addition to this peculiarity, these creatures are remarkable for the extreme agility of their movements, and their loud, unearthly cries, which resound morning and evening through the forests frequented by these animals, and in imitation of which the hoolock of Assam and Burma takes its name. Although the confined limits of a cage in the Zoological Gardens are far from favorable for displaying the marvelous rapidity of the movements of these creatures—so rapid indeed that birds on the wing are not unfrequently captured—yet the specimen which has been photographed so excellently by Mr. Ranyard indulges in the most frolicsome antics among the ropes and branches placed in its cage, to the manifest delight of all spectators. Equally well marked is the delicacy of touch possessed by the gibbons; this being shown when they amuse themselves by playing with spiders, which they allow to descend by spinning a thread attached to a finger, and then suddenly jerking them back into their hands, when the unfortunate performers are devoured with much apparent gusto.—*Knowledge*.

DIGESTION IN PLANTS.*

By Prof. J. R. Green, M.A., D.Sc., Professor of Botany to the Pharmaceutical Society.

In the processes of nutrition in plants two essentially different modes of procedure have made themselves prominent. Constructive methods are most easily visible in the great majority of plants, but are intermittent. Necessarily, therefore, there must be a further accessory series of operations to supply the requisite pabulum when construction is in abeyance. While the latter process is active, an excess of elaborated material is prepared, and the surplus deposited in the tissues temporarily, reservoirs of nutritive material of various kinds being found in many different regions. The utilization of these materials involves processes of decomposition, complex substances being split up into more simple ones, capable of removal and immediate assimilation. In plants, as in animals, a process of digestion thus results, being effected by the agency of enzymes or ferments, which seem to be formed entirely with a view to the utilization of the deposited reserve materials.

The determination of the distribution of the ferments is facilitated by first ascertaining where and in what forms the reserve materials are deposited, but in some cases the detection is difficult. Somewhere in the neighborhood of these reserve materials, however, the enzymes may be expected to occur. The microscope will show their presence, if any peculiarities of structure or distinctive reactions are associated with

* Abstract of a paper in *Science Progress*.

them, or they may be placed under such conditions as will lead to their action and the formation of recognizable products. Both methods are difficult, but both have also proved more or less successful in practice.

As regards the localization of the ferment-containing tissue, in the simplest cases of secretion the ferment is formed in the same cell as its appropriate reserve material, and its presence will be evident on microscopical examination, after warming the tissue to about 40° C. for some time. In comparatively lowly vegetable growths, too, the enzyme is probably coterminous with the cell protoplasm. In higher plants, however, more approach to specialization is seen, though even among these there are conspicuous cases of a very wide distribution, as in the case of diastase.

As the result of prolonged and painstaking researches, it has been made clear that the ferment and the glucoside on which it works are always inclosed in different cells. In roots they are distributed chiefly in the cortex, but sparsely in the wood. The pericycle and the tissue derived from it form their chief seat, the secondary bast coming next in order. They may also be found in the medullary rays and pith. In leaves the secreting cells occur throughout the mesophyl, but may be localized either there, in the pericycle, or in the bast of the veins, and occasionally occur in the endodermis of the bundles. In flowers secreting cells are contained in large numbers in both sepals and petals, but they are most numerous in the pulp of the fruit, while in seeds they may occur in the embryo and integument, in the parenchyma of the cotyledons and in the lower epidermis when the cotyledons become green.

A RECENT CONVERSAZIONE OF THE ROYAL SOCIETY.

A RECENT conversazione of the Royal Society was held at Burlington House under the presidency of Lord Kelvin. The following abstract is given in the *Engineer:*

Mr. Shelford Bidwell, F.R.S., brought under the notice of those present a new phenomenon in optics, which he had first made public at the previous meeting of the Royal Society. A disk of thin metal with a round hole in it was caused to turn in the optical lantern, and on the screen it threw the little disk, H, which moved round in the larger circle represented in Fig. 1. H was of a green color, because the rays were

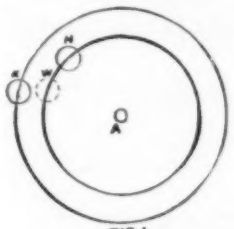


FIG. 1.

passed through a plate of green glass in front of the lantern. When caused to travel at a certain velocity, it was seen by the eyes of most persons to be followed in a larger circle by the ghost image, K, which was of a violet color; it seemed to describe the larger circle because of the unsteadiness of the eye, and when the eye was firmly fixed on the center, A, the ghost image seemed to travel on the inner circle, as at W. It was not a case of complementary colors, otherwise K would have appeared to be red instead of violet. The more slowly H moves, the nearer to it is the ghost image, K; the latter is aways a fifth of a second behind K. Mr. Bidwell thinks the effect to be almost entirely due to some action upon those nerve fibers in the retina which are sensitive to violet. He also exhibited a modified form of Charpentier's experiment, demonstrating the brief period of insensibility to luminous impressions which follows the impact of light upon the eye; Mr. Bidwell did it by strong transmitted light, instead of using Charpentier's opaque disks with sectors viewed by reflected light.

Mr. G. J. Snelus, F.R.S., described the Walrand-Legénisel process of steel manufacture as applied to steel castings. This process, he said, is a modification of the ordinary acid Bessemer process, the object being to make solid steel suitable for castings and so fluid that small converters down to 5 cwt. can be successfully used, thus enabling ordinary founders to make their own steel castings. The process consists in adding about 7 per cent. ferro-silicon, containing 10 per cent. silicon, to the metal in the converter at the end of the ordinary blow, then blowing again for about two minutes. The combustion of the added silicon produces so much heat that in two minutes the temperature of the steel is increased 250 deg. C., and the steel, therefore, is very much more fluid and sounder than ordinary steel. If pure materials are used, it is equal to crucible steel. He also exhibited what he called "the triumph weldless chain," and added that this chain is made from best steel wire by a machine of American invention, one machine taking the wire from the coil, straightening it, and making the links and chain complete at the rate of from 100 ft. to 300 ft. per hour. The chain, he said, is twice as strong as the best welded chain of equal weight, and is suitable for all engineering purposes, especially for yachts, where lightness and strength are important, driving machinery, horse, cow, and dog chains, window sashes and picture hanging. It is made by the Weldless Chain Company, St. Helens, Lancashire.

Professor Elisha Gray exhibited what he has called the "telautograph," in which the principle of the pantagraph is applied to electric telegraphy. Four line wires are required for the instrument. The writer at one station uses a lead pencil, attached mechanically to the apparatus, and writing upon ordinary paper transmits to the distant station a facsimile of his handwriting, at his ordinary writing speed. Sketches, sketch portraits, diagrams, plans, trade-marks and the like, as well as the characters of hieroglyphic alphabets, may also be transmitted. In the experiments with the apparatus, resistance equal to four miles of line wire was inserted between the two instruments, and when care is taken to keep the pencil always on the paper, it was stated that the sender could write at the rate of thirty or thirty-five words per minute, with successful transmission. It is a step by step system of signaling, and it was stated that a three or four watts current is sufficient to work through twelve or fifteen miles of line wire. The receiving instrument works with considerable force, as can be felt by holding the writing portion in the fingers. This telegraph should be of special interest to those illustrated newspapers which sometimes wish to send drawings, say from a seat of war, quickly. The instruments have but just arrived in England, and the representatives of Professor Gray are to be found at 16 St. Helen's Place, London.

Professor Oliver Lodge exhibited a sensitive detector of electric radiation and an emitter of the same. He said that electric charges suddenly imparted to a sphere or other conductor oscillate a few times before settling down in equilibrium, and these oscillations emit waves into the ether, which are in all respects light, except that they are not visible, being much too big. Hertz first experimentally proved their existence. To-day the detection of them is easy, and the most sensitive detector, he stated, is now exhibited in a compact and portable form. It consists of a minute battery galvanometer and a bad joint, all inclosed in a small cylinder 3 in. by 2 in. The rest of the instrument is a lamp and scale. Electric waves being generated in the neighborhood, the resistance of the bad joint varies, and the galvanometer is disturbed. With this receiver all ordinary optical experiments can be repeated, using the long electric waves instead of the ultra-microscopic waves of the same kind to which the eye responds.

Mr. J. Wimshurst exhibited models showing an improved method of communication between shore stations and lightships, or other like purposes. The method consists of arranging suitably wound coils of insulated wire, A B, upon the swivel pin, K K—Fig 2—of the moorings, the one coil being in communication

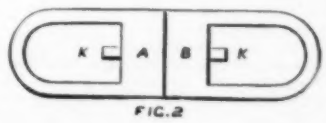


FIG. 2

with the shore station and the second coil in communication with the ship. Signals or sound are transmitted by induction or by electro-magnetic induction. This arrangement is more especially for telephonic communication. Mr. Wimshurst, however, stated that he lighted a lamp through it by induction.

Miss Edna Walter, B.Sc., and Mr. H. B. Bourne exhibited a projective goniometer. By means of this instrument, devised and constructed by the exhibitors, the projection of a crystal on a sphere is actually accomplished, realizing in practice the fundamental assumption of the theory of crystallography; the instrument is thus of value in demonstrating the axioms of the science. If necessary, angular measurements can be made from the image, but these only attain an accuracy of about 40' in 60 deg. = one per cent., which is inferior to that attained with a goniometer.

Professor Silvanus P. Thompson, F.R.S., among other things exhibited the revolution of a large copper egg, of an oval block of aluminum, and of a watch in a rotary magnetic field. Fig. 3 will give an idea

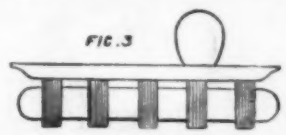


FIG. 3

of the arrangement, which consisted of a massive ring of soft iron, with coils of wire round it at intervals, through which coils an electrical current could be sent in a suitable manner. The egg lying down would begin to spin, and at last work itself upright, and spin on end.

The Postmaster-General exhibited a Wheatstone's automatic transmitter, running up to 600 words per minute, driven by Willmot's air motor. The air motor in this instrument dispenses with the 42 lb. weight which, when the instrument is running at 600 words per minute, requires rewinding by the operator every few seconds. The air motor being applied directly to the eccentric axle dispenses with the whole of the train of wheelwork, the friction regulator, and complicated flywheel. The speed of the instrument is regulated by opening or contracting the nozzle regulating the supply of air. The power required is so small that the instrument can be driven at a moderate speed by simply blowing into it with the mouth. He also exhibited Professor Hughes' type printing telegraph, driven by Willmot's air motor. The air motor in this instrument takes the place of the 132 lb. weight previously used, and dispenses with the whole of the winding gear, and nearly all the train of wheelwork, the motor being applied directly to the printing shaft. The air motor is self-starting in any position, and will run continuously without any aid from the operator. When running by means of compressed air, the instrument is more steady than when driven by weight, due to the fact that there is less weight in the whole instrument.

Mr. Claude Vautin exhibited some white coherent lumps of metallic tungsten, a metal which has not been seen in such a state of aggregation before. He also exhibited specimens of metallic chromium, manganese and iron, free from carbon, as well as fused alumina, obtained during reduction of the metallic samples. The specimens had been reduced from their oxides by means of metallic aluminum. The oxide of the metal to be reduced was intimately mixed with finely divided aluminum, and heated in magnesia-lined crucibles.

Professor Norman Lockyer exhibited some maps and plans which accompanied the report of the Egyptian government on the Nile reservoirs. Sir David Salomons exhibited two new contact makers and breakers for induction coils. Professor C. V. Boys exhibited photographs of apparatus used by him in finding the Newtonian constant of gravitation. Lord Ross exhibited some original drawings of the Milky Way, made at the Birr Castle Observatory. Messrs. Thornycroft & Company exhibited models of torpedo boats and of their water tube boiler. Mr. Charles Bradbury exhibited a new calculating machine. Mr. C. T. Snedder exhibited apparatus for heating pillows, pads and such like things by electricity for hospital purposes. Mr. J. W. Swan exhibited gold leaves made by electrical deposition, quite transparent and transmitting green light. Mr. W. Kurtz, of New York, exhibited photograph prints, in which the colors of nature were imitated by synthesis, by the process of Dr. H. W. Vogel, of Berlin.

STUDY OF FLUID MOTION BY MEANS OF COLORED BANDS.*

By Prof. OSBORNE REYNOLDS, F.R.S.

IN his charming story of "The Purloined Letter," Edgar Allan Poe tells how all the efforts and artifices of the Paris police to obtain possession of a certain letter, known to be in a particular room, were completely baffled for months by the simple plan of leaving the letter in an unsealed envelope in a letter rack, and so destroying all curiosity as to its contents; and how the letter was at last found there by a young man who was not a professional member of the force. Closely analogous to this is the story I have to set before you to-night—how certain mysteries of fluid motion, which have resisted all attempts to penetrate them, are at last explained by the simplest means and in the most obvious manner.

This, indeed, is no new story in science. The method adopted by the minister, D., to secrete his letter appears to be the favorite of nature in keeping her secrets, and the history of science teems with instances in which keys, after being long sought among the grander phenomena, have been found at last, not hidden with care, but scattered about, almost openly, in the most commonplace incidents of everyday life which have excited no curiosity.

This was the case in physical astronomy—to which I shall return after having reminded you that the motion of matter in the universe naturally divides itself into three classes.

(1) The motion of bodies as a whole—as a grand illustration of which we have the heavenly bodies, or more humble, but not less effective, the motion of a pendulum, or a falling body.

(2) The relative motion of the different parts of the same fluid or elastic body, for the illustration of which we may go to the grand phenomena presented by the tide, the whirlwind or the transmission of sound, but which is equally well illustrated by the oscillatory motion of the wave, as shown by the motion of its surface and by the motion of this jelly, which, although the most homely illustration, affords by far the best illustration of the properties of an elastic solid.

(3) The inter-motions of a number of bodies among each other, to which class belong the motions of the molecules of matter resulting from heat, as the motions of the molecules of a gas, in illustration of which I may mention the motions of individuals in a crowd, and illustrate by the motion of the grains in this bottle when it is shaken, during which the white grains at the top gradually mingle with the black ones at the bottom, which inter-diffusion takes an important part in the method of colored bands.

Now of these three classes of motion that of the individual body is incomparably the simplest. Yet, as presented in the phenomena of the heavens, which have ever excited the greatest curiosity of mankind, it defied the attempts of all philosophers for thousands of years, until Galileo discovered the laws of motion of mundane matter. It was not until he had done this and applied these laws to the heavenly bodies that their motions received a rational explanation. Then Newton, taking up Galileo's parable and completing it, found that its strict application to the heavenly bodies revealed the law of gravitation and developed the theory of dynamics.

Next to the motions of the heavenly bodies, the wave, the whirlwinds and the motions of clouds, had excited the philosophical curiosity of mankind from the earliest time. Both Galileo and Newton, as well as their followers, attempted to explain these by the laws of motion, but, although the results so obtained have been of the utmost importance in the development of the theory of dynamics, it was not till this century that any considerable advance was made in the application of this theory to the explanation of fluid phenomena; and although during the last fifty years splendid work has been done, work which, in respect of the mental effort involved, or the scientific importance of the results, goes beyond that which resulted in the discovery of Neptune, yet the circumstances of fluid motion are so obscure and complex that the theory has yet been interpreted only in the simplest cases.

To illustrate the difference between the interpretation of the theory of heavenly bodies and that of fluid motion, I would call your attention to the fact that solid bodies, on the behavior of which the theory of the motion of the planets is founded, move as one piece, so that their motion is exactly represented by the motion of their surfaces; that they are not affected with any internal disorder which may affect their general motion. So surely is this the case that even those who have never heard of dynamics can predict with certainty how any ordinary body will behave under any ordinary circumstances, so much so that any departure is a matter of surprise. Thus I have here a cube of wood, to one side of which a string is attached. Now hold it on one side, and you naturally suppose that when I let go holding the string it will turn down so as to hang with the string vertical; that it does not do so is a matter of surprise. I place it on the other side and it still remains as I place it. If I swing it as a pendulum, it does not behave like one.

Would Galileo have discovered the laws of motion had his pendulum behaved like this? Why is its motion peculiar? There is internal motion. Of what sort? Well, I think my illustration may carry more weight if I do not tell you; you can all, I have no doubt, form a good idea. It is not fluid motion, or I

* A lecture delivered at the Royal Institution of Great Britain.—*Nature.*

should feel bound to explain it. You have here an ordinary looking object which behaves in an extraordinary manner, which is yet very decided and clear, to judge by the motion of its surface, and from the manner of the motion I wish you to judge of the cause of the observed motion.

This is the problem presented by fluids, in which there may be internal motion which has to be taken into account before the motion of the surface can be explained. You can see no more of what the motion is within a homogeneous fluid, however opaque or clear, than you can see what is going on within the box. Thus without color bands the only visual clew to what is going on within the fluids is the motion of their bounding surfaces. Nor is this all; in most cases the surfaces which bound the fluid are immovable.

In the case of the wave on water the motion of the surface shows that there is motion, but because the surface shows no wave, it does not do to infer that the fluid is at rest.

The only surfaces of the air within this room are the surfaces of the floor, walls and objects within it. By moving the objects we move the air, but how far the air is at rest you cannot tell unless it is something familiar to you.

Now I will ask you to look at these balloons. They are familiar objects enough, and yet they are most sensitive anemometers, more sensitive than anything else in the room; but even they do not show any motion; each of them forms an internal bounding surface of the air. I send an aerial messenger to them, and a small but energetic motion is seen by which it acknowledges the message, and the same message travels through the rest, as if a ghost touched them. It is a wave that moves them. You do not feel it, and, but for the surfaces of the air formed by the balloons, would have no notion of its existence.

In this tank of beautifully clear distilled water I project a heavy ball in from the end, and it shows the existence of the water by stopping almost dead within two feet. The fact that it is stopped by the water, being familiar, does not raise the question, Why does it stop?—a question to which, even at the present day, a complete answer is not forthcoming. The question is, however, suggested, and forcibly suggested, when it appears that with no greater or other evidence of its existence, I can project a disturbance through the water which will drive this small disk the whole length of the tank.

I have now shown instances of fluid motion of which the manner is in no way evident without color bands, and were revealed by color bands, as I showed in this room sixteen years ago. At that time I was occupied in setting before you the manners of motion revealed, and I could only incidentally notice the means by which this revelation was accomplished.

Among the ordinary phenomena of motion there are many which render evident the internal motion of fluids. Small objects suspended in the fluid are important, and that their importance has long been recognized is shown by the proverb, Straws show which way the wind blows. Bubbles in water, smoke and clouds, afford the most striking phenomena, and it is doubtless these that have furnished philosophers with such clews as they have had. But the indications furnished by these phenomena are imperfect, and, what is more important, they only occur casually, and in general only under circumstances of such extreme complexity that any deduction as to the elementary motions involved is impossible. They afford indication of commotion, and perhaps of the general direction in which the commotion is tending, but this is about all.

For example, the different types of clouds; these have always been noticed, and are all named. And it is certain that each type of clouds is an indication of a particular type of motion in the air, but no deductions as to what definite manner of motion is indicated by each type of cloud have ever been published.

Before this can be done it is necessary to reverse the problem and find to what particular type of cloud a particular manner of motion would give rise. Now a cloud, as we see it, does not directly indicate the internal motion of which it is the result. As we look at clouds, it is not in general their motion that we notice, but their figure. It is hard to see that this figure changes while we are watching a cloud, though such a change is continually going on, but is apparently very slow on account of the great distance of the cloud and its great size. However, types of clouds are determined by their figure, not by their motion. Now what their figure shows is not motion, but it is the history or result of the motion of the particular strata of the air in and through surrounding strata. Hence, to interpret the figures of the clouds, we must study the changes in shape of fluid masses, surrounded by fluid, which result from particular motions.

The ideal in the method of color bands is to render streaks or lines in definite position in the fluid visible, without in any way otherwise interfering with these properties as part of the homogeneous fluid. If we could by a wish create colored lines in the water, these would be ideal color bands. We cannot do this, nor can we exactly paint lines in the air or water.

I take this ladle full of highly colored water, lower it slowly into the surface of the surrounding water till that within is level with that without; then turn the ladle carefully round the colored water; the mass of colored water will remain where placed.

I distribute the color slowly. It does not mix with the clear water, and although the lines are irregular, they stand out very beautifully. Their edges are sharp here. But in this large sphere, which was colored before the lecture, although the colored lines have generally kept their places, they have, as it were, swollen out and become merged in the surrounding water in consequence of molecular motion. The sphere shows, however, one of the rarest phenomena in nature—the internal state in almost absolute internal rest. The forms resemble nothing so much as stratus clouds, as seen on a summer day, though the continuity of the color bands is more marked. A mass of colored water once introduced is never broken. The discontinuity of clouds is thus seen to be due to other causes than mere motion.

Now, having called your attention to the rarity of water at rest, I will call your attention to what is apt to be a very striking phenomenon, namely, that when water is contained, like this, in a spherical vessel of which you cannot alter the shape, it is impossible by moving the vessel suddenly to set up relative motion in the interior of the water. I may swing this vessel about and turn it, but the color band in the middle remains as it was, and when I stop shows the water to be at rest.

This is not so if the water has a free surface, or if the fluid is of unequal density. Then a motion of the vessel sets up waves, and the color band shows at once the beautifully lawful character of the internal motion. The color bands move backward and forward, showing how the water is distorted like a jelly, and as the wave dies out the color bands remain as they were to begin with.

This illustrates one of the two classes of internal motion of water or fluid. Wherever fluid is not in contact with surfaces over which it has to glide, or which surfaces fold on themselves, the internal motions are of this purely wave character. The color bands, however much they may be distorted, cannot be relatively displaced, twisted, or curled up, and in this case motion in water once set up continues almost without resistance. That wave motion in water with a free surface is one of the most difficult things to stop is directly connected with the difficulty of setting still water in motion; in either case the influence must come through the surfaces. Thus it is that waves once set up will traverse thousands of miles, establishing communication between the shores of Europe and America. Wave motion in water is subject to enormously less resistance than any other form of material motion.

(To be continued.)

NICOLAS SAVIN.

A FRENCH SOLDIER 126 YEARS OF AGE.

FOR several weeks past the Russian journals have had considerable to say about an extraordinary old man who, since 1812, has lived in the city of Saratow, upon the Volga, and who is one of the survivors of the Grand Army of Napoleon I. He was made a prisoner of war by the Cossacks of Platow during the retreat from Beresina.

We give herewith a portrait of this veteran, reproduced from a Russian journal of Moscow, the *Novoie Vremia*. Mr. A. Voensky, one of the editors of this journal, made the acquaintance of the old man at the beginning of this year, and, after numerous conversations with him, gradually succeeded in learning the history of his adventures.

Nicolas Savin was born at Paris on April 17, 1768. His father served under Louis XIV., in the French guards. He studied at the college of the Jesuits at Tours, where one of his uncles lived. At the beginning of 1792, Savin joined his father, who occupied a position at the court of Versailles. It was at the

NICOLAS SAVIN,
A Soldier of the Grand Army, 126 Years of Age.

epoch of the September massacres. Having found an asylum at the house of a friend in Paris, he lived there. He still recalls the day of the execution of Louis XVI. and the horrors of the Reign of Terror. He left Paris in 1794, and resided in Rouen until 1798, the epoch at which General Bonaparte reformed the army at Havre, which he called from volunteers for the expedition against England. Savin enlisted and was soon enrolled in the second regiment of hussars, with which he went on the most important campaigns of the consulate and the empire.

The new soldier started for Toulon, where his regiment was quartered. He embarked, and did not know until he was at sea that his destination was Eygpt. He went through the entire campaign. After that of Egypt, he participated in the war of Spain. Having been wounded at Saragossa, he was made chevalier of the Legion of Honor. Later on he was taken by the Spaniards, but succeeded in escaping from prison, and rejoined his regiment. In 1805 he fought at Austerlitz, and in the following year took part in the battle of Jena. He found himself in the escort of honor that proceeded to Berlin. He was not far from Napoleon at the time of the celebrated visit that the great captain made to the tomb of Frederick the Great.

In 1812, the Second Hussars formed part of the third corps of the grand army under the command of Marshal Ney, with whom he made the entire campaign of Russia from the Niemen as far as to Moscow and the retreat. The brave soldier had several horses killed under him at Krasnoe, and his army corps was entirely destroyed. On reaching Beresina, there were but a few men left, who were exhausted by the marches, hunger and cold. Savin still recalls the care that the great surgeon Larrey bestowed upon all the men.

After having again been made a prisoner, our soldier finally returned to France. We shall here finish the dramatic history of the heroic old man, who has lived at Saratow for eighty-two years. He gives proof that the longevity of the ancients is not a fable. He lives with his daughter, a nice old maid.

"Every time that I approach the dwelling of the honorable old man," says Mr. Voensky, "I experience a feeling of respect analogous to that which overcomes the tourist under the dome of the Pantheon, Coliseum or other monuments of the olden time."

Savin is much beloved at Saratow. He lives in a modest room, wherein is to be seen the portrait of the old hussar and that of Napoleon.

In 1887, the Emperor of Russia took notice of Savin and sent him a present of 1,000 rubles. Even now the old soldier cannot help exhibiting deep emotion when he speaks of the Czar's generosity.—*La Nature.*

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ARMS AND AMMUNITION.—The Modern War Gun.—With sections showing the mechanism of the Daudeteau, Mauser, and Mannlicher guns.—4 illustrations 15495

II. BIOGRAPHY.—Nicolas Savin.—A soldier of the grand army of Napoleon First, now 126 years of age.—Portrait 15510

III. BOTANY.—Digestion in Plants.—By Prof. J. R. GREEN 15509

IV. CHEMISTRY.—Lead Water Pipes.—Description of tests 15501
Liquid Air.—By J. J. STEWART.—A valuable paper detailing the remarkable experiments of Faraday, Pictet, Cailletet, Wroblewski, Olszewski and Prof. Dewar 15501
Varnishes.—The analysis of 15500

V. CIVIL ENGINEERING.—The Catastrophe at Lima, Montana.—By J. M. GOODWIN 15498
Suction Dredger, Smaulders'.—A powerful suction pump dredge for use in canal and harbor work.—1 illustration 15498
The Zuider Zee and the Draining of the Zuider Zee.—Two articles on this wonderful engineering work, which bids fair to reclaim $150,000,000 worth of land.—Map 15499

VI. EDUCATION.—Technical Education.—By L. S. LEVY.—Prize essay, delivered before the Hebrew Technical School 15497

VII. ELECTRICITY.—A Recent Conversazione of the Royal Society.—Several new experiment in optics and electricity are described by Mr. Wimshurst, Prof. S. P. Thompson, and others.—3 illustrations 15503

VIII. NATURAL HISTORY.—The Æpyornis.—A bird of Madagascar which has recently become extinct.—3 illustrations 15506
The Man-like Apes.—By R. LYDEKKER 15507

IX. PHOTOGRAPHY.—Recent Photographic Lenses.—1 illustration 15503

X. PHYSICS.—Study of Fluid Motion by Means of Colored Bands.—By Prof. OSBORNE REYNOLDS, F.R.S.—The first installment of Prof. Reynolds' valuable researches 15509

XI. TECHNOLOGY.—The American Oilcloth Industries.—Interesting particulars of the rise and progress of this industry, with details of manufacture.—Abstract of speech of Hon. M. S. QUAY in United States Senate 15496
The Schoenaeler Phosphor-Copper Process.—Phosphor-copper containing a very high percentage of phosphorus (up to 30 per cent.) and phosphor-bronze 15500

XII. TRAVEL.—A Summer Voyage to Italy, the Azores, Gibraltar, Genoa.—A very readable account of a trip through the western Mediterranean.—7 illustrations 15507

CATALOGUES.

A Catalogue of Valuable Papers contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address; also, a comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of authors. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address

MUNN & CO., 361 Broadway, New York.

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *forty-five years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them; directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases. Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.